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PROCEEDINGS

OF THE

BIRMINGHAM NATURAL HISTORY

AND

PHILOSOPHICAL SOCIETY.

NATURAL HISTORY SOCIETY, FOUNDED 1858.

PHILOSOPHICAL SOCIETY, FOUNDED 1876.

AMALGAMATED 1894.

"NATURÆ SPECIES RATIOQUE."

Lucretius.

VOL. X.—PART I.—SECTION I.

RECORDS

OF

METEOROLOGICAL OBSERVATIONS

FOR 1896,

TAKEN AT THE OBSERVATORY OF THE

BIRMINGHAM AND MIDLAND INSTITUTE,

WITH

Charts of the Five Yearly Means for 1887-1891 and 1891-1896.

[The accompanying Records and Charts have been drawn up by Mr. Cresswell at the request of the Society, and are published by permission of the Council of the Midland Institute.

HUDSON AND SON, PRINTERS, EDMUND STREET, BIRMINGHAM.

RECORDS

OF

METEOROLOGICAL OBSERVATIONS

TAKEN AT THE OBSERVATORY OF THE

BIRMINGHAM AND MIDLAND INSTITUTE

MR. ALFRED CRESSWELL,

CURATOR OF THE OBSERVATORY.

[The accompanying Records and Charts have been drawn up by Mr Cresswell at the request of the Society, and are publ shed by permission of the Council of the Midland Institute.

Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, The Monument, Waterworks Road, Edgbaston, Birmingham.

The Observatory is situated in North Latitude 52° 28′ 24″, and West Longitude 1° 55′ 40″, and is at an average elevation of 500 feet above the mean sea level.

Barometer.

The cistern of the standard barometer is 541 feet above the mean sea level, and the barometer is read twice daily, at 9 a.m. and at 9 p.m.

Temperature.

The temperatures given are the highest, lowest, and the 9 a.m. readings, from maximum and minimum thermometers, placed four feet above the ground in the shade. The solar radiation is the maximum temperature given by a blackened bulb thermometer in vacuo, exposed to the direct rays of the sun.

Rain.

The amount is given from a gauge placed one foot above the ground, and 525 feet above the mean sea level.

Sunshine.

The amount of sunshine has been obtained by a Jordan's sunshine recorder, placed on the top of The Monument, about 100 feet above the ground.

Horizontal Motion of the Air.

A continuous record has been obtained by means of Robinson's hemispherical cups, in connection with Osler's anemometer, which is situated on the top of The Monument, about 100 feet above the ground; the velocity being obtained on the assumption that the cups move with one-third the velocity of the air.

Extreme Wind Pressure.

The pressure plate of Osler's anemometer, from which this record has been obtained, presents a surface of two superficial feet to the wind. The direction at the time of greatest pressure, given to the nearest sixteenth point of the compass, has also been obtained from this instrument.

For all the self-recording instruments the day begins and ends at midnight. The maximum and minimum thermometers and the rain gauge have been read twice daily, at 9 a.m. and 9 p.m. The temperatures and rainfall thus recorded may be taken generally as occurring on the day for which they are entered.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Temperature.	Corrected to Sea Level.	At 9 a m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Jan. 1	29·539	30·114	M.	C.	45·6	49 0	44·2	51·8
2	29·530	30·105	C.	C.	50·0	50·2	45·3	51·7
3	29·608	30·185	M.	C.	41·8	46·1	37·9	45·0
4	29 686	30·264	F.	O.	38·4	41·7	35 5	41·9
5	29·953	30·537	O.	O.	36·8	41·5	35·6	41·5
6	30·060	30·646	M.	O.F.	31·0	36·3	29·0	36·0
7	30·097	30·683	O.	O.	30·8	37·4	28·0	37 4
8	30·148	30·735	O.	O. to C.	39·8	43·2	37·3	45·7
9	**30·334**	**30·925**	C.	C.	35·4	39·3	34·4	46·0
10	30·243	30·832	C.	C.	33·1	37·2	32·5	57·2
11	30·112	30 699	O.	C.	40·0	40·0	35·3	45 0
12	29·792	30·372	O.	C.	38·6	39·0	33·4	44·1
13	29·364	29·936	C.B.	C.B.toC.toR	37·4	42 0	36 4	64·0
14	28·754	29·314	O.	C.	42·0	46·2	34·3	61·7
15	28·901	29·468	C.	C.R.B.	47·1	**50·8**	33·7	74 8
16	29·391	29·963	C.	C.	42·5	48 4	38·2	56·5
17	29·518	30·093	C.	C B.	46·8	50 4	45·6	86·8
18	29·581	30·157	C.B.	B.C.	44·4	48·8	42 5	**87·0**
19	29·712	30·291	C.B.	B.C.	40·3	46·0	38·4	81·4
20	29·894	30·476	M.	C.toC.B.Hz	35·4	41·8	32·0	68·4
21	29·826	30·407	O.	C.	29·8	36·4	28·8	52 0
22	29·651	30·229	C.	O.	34·0	39·6	27·2	47·3
23	29·704	30·283	C.	C.	34 0	37·9	32·4	45·8
24	29·474	30·058	C.	C.	40·0	43·6	37·2	59 0
25	29·292	29·862	R.	R.	47·4	49·5	42·4	55·0
26	29 616	30 193	M.	C.	44 0	48·5	43·4	55·9
27	29·676	30·254	O.	O.	45·6	49·0	43·3	49·9
28	29·800	30·381	B.	C B.	37·8	48·8	36·2	79·0
29	30·200	30·789	C.	C.B.	39·4	43·0	34·9	59·0
30	30·252	30 842	O.	C.	39·4	41·7	35·6	45 3
31	30·208	30·797	O.	C.	40 0	41·4	38·2	44·0
Extreme Mean, or Sum.	**30·334** 28·754				39·6	**50·8**	27·2	**87·0**

NOTE.—Heavy type indicates maximum or in large quantities ;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Jan. 1	...	...	...	258	10·7	...	...	...
2	...	...	...	326	13·6	1·0	8·30	S.S.W.
3	...	...	...	139	5·8	...	...	...
4	...	...	...	243	10 1	...	..	...
5	..	...	...	186	7 7	...	...	...
6	...	.	...	96	4·0	...	...	..
7	...	...	...	153	6·4	...	...	...
8	...		...	307	12·8	1 0	*3 10*	N.N.E.
9	...	..	...	310	12 9	1·0	2·10	N.E.
10	...	...	...	270	11·2	0·7	*6·25*	N.N.W.
11	0·020	...	.	266	11·1	...	...	...
12	..	...	...	260	10·8	0·7	*9·50*	W.S.W.
13	0·090	1	40	317	13·2	1·4	*11·50*	S.S.W.
14	0·020	...	20	352	14·7	6·0	7·55	N.W.
15	0·210	2	0	**591**	**24·6**	**12·0**	*2·20*	**W.N.W.**
16	...	...	...	509	21·2	5·0	12·10	W.N.W.
17	..	2	50	422	17·6	4·0	1·35	W.
18	...	4	30	259	10·8	1·0	10·10	W.S W.
19	...	5	15	175	7·3	...	...	...
20	...	2	0	154	6 4	...	...	...
21	...	...	30	128	5·3	...	..	...
22	...	...	...	197	8·2	...	...	..
23	...	...	...	177	7·4	...	..	...
24	...	...	45	430	17 9	3·0	*1·10*	S.S.W.
25	**0·690**	...	..	241	10·0	...	...	...
26	...	...	...	147	6·1	...	...	...
27	0·010	..	...	363	15·1	1·5	*6·50*	S.S.W.
28	0·110	**5**	**30**	278	11·6	1·0	10·50	W.N.W.
29	...	...	20	225	9·4	...	...	...
30	...	...	...	259	10·8	1·0	*1·50*	N.W.
31	...	...	...	146	6·1	...	...	...
Extreme Mean, or Sum.	1·150	25	40	8184	11·0	**12·0**	*2·20*	**W.N W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Feb. 1	30·035	30 620	O.	C.	36·0	39·0	31·4	40·4
2	29 946	30 529	C.	B C.	33·0	40·8	28·6	73·2
3	**20·116**	**30·703**	B,M.	B.C.	33·5	40 0	32·6	63·6
4	29·994	30·558	B	B.	33·0	44·2	32·0	82·7
5	29·908	30·491	B,M.	B.C.	39·8	52·7	36·8	92·7
6	29·935	30·518	O.	C.	40 8	46 4	37·1	52·6
7	29·834	30·415	C.B.	C.	40 5	41·8	35·7	54 3
8	29·538	30·113	O.	C. to R.	45·9	52·9	39·0	77·9
9	29·583	30·159	B.C.	B.	44·6	51·9	41·0	**100·2**
10	29·802	30 383	B.Hz.	B	37 8	51·2	35·1	89 0
11	29·845	30·426	B.Hz.	C R.	44·2	51 0	38·8	68 9
12	29 699	30·377	B.	B.	44·8	52 9	38 7	95·0
13	29 864	30·446	O.	O.	43 0	48 0	40·7	52·4
14	29 876	30 458	D.	O.	40 0	45·2	39·0	57·9
15	29·871	30·453	O.	O.	39·7	44·7	36 2	52·0
16	30·035	30·620	O.	O.	34·6	44·8	32·0	38·6
17	29 954	30·538	O.	O.	32·0	34·2	30·7	43·1
18	29·707	30·286	F.	O.	26·4	33·2	26·0	38·6
19	29·267	29·837	M.	O. to B.C	37 8	**53·8**	30·8	89·4
20	29·089	29.655	O.	D to R.	47·0	49·8	45·1	59·8
21	29·199	29·767	B.	B.C. to R	38·1	50·1	35·7	89 4
22	29 399	29·971	B.Hz.	B.C.Hz.	36·4	45·2	33·5	81·4
23	29·750	30·330	B.Hz.	B.C	31 2	38·2	28·2	78 0
24	29 893	30·475	C.B.	B.C.	29·0	39·7	28·0	84·2
25	29·756	30·336	C	C B.	28·0	33·9	25·7	73·9
26	29·495	30·069	C.	C.	28·2	35 7	24·4	63 9
27	29 652	30·230	O.	C.B.	34·4	45 6	26·4	68·4
28	29·571	30·147	C.	C.B.	47·5	51·7	45·1	96 1
29	29·517	30·092	R.	C	48·8	50·8	42·1	73·9
Extreme Mean, or Sum.	**30·116** 29·089				37.6	**53·8**	24·4	**100·1**

NOTE.—Heavy type indicates maximum or in large quantities;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz.—Hazy. M.=Mist. O.=Overcast. R.=Rain. S.=Snow. Th.=Thunder.

DATE.	RAIN.	SUNSHINE		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Feb. 1	...	...	..	120	5·0	...	...	...
2	...	1	25	148	6·2	..	...	...
3	...	1	25	242	10·1	0·8	*3·35*	E.S.E.
4	...	6	40	199	8·3	...	...	...
5	...	3	0	246	10·3	...	...	...
6	...	...	...	204	8·5	...	..	...
7	...	...	40	378	15·7	3·0	*11·5*	S.
8	0·035	...	35	**508**	**21·2**	**5·0**	*2·20*	**S.S.W.**
9	0·040	6	50	288	12·0	1·6	*1·25*	W.
10	...	5	25	247	10 3	0·8	11·30	W.
11	...	1	20	318	13·3	2·0	*6·10*	W.S.W.
12	...	8	35	441	18·4	4·6	*2·0*	W.
13	0·085	...	...	204	8·5	...	...	...
14	0·020	...	...	194	8·1	...	...	...
15	...	...	...	200	8·3	...	...	...
16	...	...	...	161	6 7	...	...	...
17	...	.	...	223	9 3	...	...	...
18	...	...	...	151	6·3	...	...	...
19	...	4	0	281	11·7	1·4	*6·25*	S.S.E.
20	**0·225**	...	...	291	12·1	...	...	...
21	0·115	7	0	148	6·2	...	...	...
22	...	4	15	341	14·2	1·5	*7·10*	E.
23	...	6	10	317	13·2	1·0	*12·40*	E.
24	...	5	25	256	10·7	0·6	*8·15*	E.S.E.
25	...	1	40	262	10·9	0·5	10·40	S.E.
26	...	...	15	169	7·0	...	...	...
27	...	1	10	244	10·2	1·0	*6·50*	W.
28	0·020	3	0	474	19·7	4·7	*8·25*	N.W.
29	0·025	...	...	340	14·2	2·2	10·25	W.N.W.
Extreme Mean, or Sum.	0·565	68	50	7595	10·9	**5·0**	*2·20*	**S S.W.**

Ital.=P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a m.	Highest.	Lowest.	Solar Radiation. Max.
Mar. 1	29·075	29·642	R	R.C.B.	48·4	48·4	39·6	99·6
2	28·937	29·500	B.C.	C.B.	40·8	45·6	37·8	89·5
3	28·225	28·774	B.C.	C.B.	37·8	45·6	34·9	100·0
4	28·139	28·686	C.	C.B.R.	38·6	43·9	34·0	99·4
5	28·837	29·398	B.C.	C.B.R.	40·4	46·9	35·9	93·3
6	29·099	29·665	C.	C R.	46·2	51·8	41·8	60·0
7	29·425	29·998	O.	C R.	40·9	47·2	37·5	57·1
8	29·309	29·880	R.	C.B.R.	51·2	55·9	44·0	93 0
9	29·393	29·965	O.	R.	48·3	53·1	43 0	61 0
10	**29·711**	**30·290**	M	C B.	34·7	49·1	34 1	93 6
11	29·461	30 035	C.	C	50·5	56·0	47 8	81·3
12	29·540	30·115	O.	C.B.	37 6	47·8	37·1	97·0
13	29·355	29 927	D.	R	36·0	41·8	35·2	45·2
14	29·222	29·791	O.	O	40·7	44·8	36·0	64·6
15	29·247	29·816	O.	R.	36·0	49·8	29·8	88 6
16	28·954	29·518	R.	C.B.	48·3	51·2	42·7	108·3
17	29·304	29·875	B.C.	B. to C.	43 8	52·0	37·5	101·8
18	29·065	29·631	O.	O.	39·5	50·4	38·2	59 9
19	29·365	29 937	B	B.	38·1	50·6	31·0	101 2
20	29·217	29·786	O.	C. to R.	45·0	50·8	38·6	72·7
21	29·183	29·751	C.	C. to R.	45·0	55·0	43·0	110·8
22	29·423	29·996	O.	C.	46·3	52·1	45·0	79 8
23	29·465	30·039	B C.	B.C.	48·9	57·9	40·9	**111·0**
24	29·271	29·841	O.	C.B to Th.	42 9	**63·5**	36·8	110 2
25	29·086	29·652	B.C.	C B. to C.	49·8	57·3	47·4	95·4
26	29·120	29·687	C.	C.B to R.	42 0	49·3	41·0	106·0
27	29·401	29 974	C.B.	C.B.	39·4	47·4	36·0	91·5
28	28·946	29·509	C.	C.B.R. & H.	40·4	43·0	36·5	90 8
29	29·258	29·828	B.C.	B.C.	39·5	47·3	34·1	101·0
30	29·513	30·088	C.	C.	37·8	45·9	33·2	88·3
31	29·629	30·206	B C.	C.	39·8	46·9	31·0	79·9
Extreme Mean, or Sum.	**29·711** 28·139				42·4	**63·5**	29·8	**111·0**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Mar. 1	0·110	2	35	470	19·6	6·8	*4·10*	W.N.W.
2	0·020	2	40	467	19·5	4·5	13·35	W.
3	**0·320**	5	25	584	24·3	10 5	4·0	S.W.
4	0·060	2	50	427	17 8	5·0	11·35	W.
5	0·135	3	25	565	23·5	6·0	5 30	N.W.
6	0·130	...	...	663	27 6	14 0	*8·20*	W.N.W.
7	0·250	...	...	268	11·1	6·0	12·30	W.N.W.
8	0·140	1	10	582	24 2	9·5	*3·20*	W.
9	0 145	...	...	303	12·6	4·7	12·40	W
10	...	3	55	253	10·5	1·4	*8·30*	S.S.W.
11	0·020	...	20	285	11·9	...	...	...
12	...	1	15	238	9·9	...	...	...
13	**0·320**	...	...	307	12·8	1.0	*12·35*	S.S.E.
14	0·020		...	229	9·5	...	...	...
15	0·270	..	20	323	13.5	4 4	*2 25*	W.S.W.
16	0·020	5	40	**668**	**27·8**	**19·5**	10·30	**W.**
17	...	5	10	398	16·6	4·5	*7 5*	S W.
18	0·045	...	...	213	8·9	...	...	...
19		10	10	217	9·0	1·0	*4·55*	S.S.W.
20	0 240	...		436	18·2	4.3	3·10	S.
21	0 140	2	5	191	8 0	...	...	...
22	0 010	...		86	3·6	...	...	..
23	...	**10**	**35**	179	7·5	...	...	...
24	0·020	4	0	179	7 5		...	...
25	.	2	30	225	9·4	1 0	*2 35*	S.W.
26	0·115	5	30	505	21·0	8·0	7·55	W.N.W.
27	...	5	20	487	20·3	8·5	1·25	N.W.
28	0·115	3	0	582	24·2	11·5	*2·30*	N W.
29	0 010	9	50	435	18 1	3·0	*12·10*	N.N.W.
30	...	1	45	299	12·5	...	...	...
31	...	1	10	190	7·9	...	...	...
Extreme Mean, or Sum.	2·685	90	40	11254	15·1	**19·5**	10·30	**W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m	Generally during day.	At 9 a m	Highest.	Lowest.	Solar Radia tion. Max.
April 1	29·533	30·108	O.	C.	44·8	48·9	42·8	91·8
2	29·751	30·331	C.	C,	41·0	49·6	33·4	86·6
3	29·572	30·148	C.	C.	43·1	49·2	36·3	70·9
4	29·626	30 203	C.	C.	44·0	49 0	39·7	69·0
5	29·656	30·234	C.	C.B.	47·6	57·2	45·4	111·8
6	29·646	30·223	C.	C.	49·1	57·4	44·4	82·9
7	29·695	30·273	C.	C. to C.B.	48 5	59·4	43·0	108·3
8	29·703	30·282	C.	C.	49·2	54·8	42·6	91·2
9	29·672	30·250	C.	C.B. to C.	49·2	60·0	45·4	105·3
10	29·640	30·217	C.	B.C.	43 8	55·2	43·5	107·0
11	29·305	29·876	O.	C.B Showers	45 9	48 2	41·2	98·5
12	29·290	29·860	C.B.	C.B. Showers	43·3	47·9	37·4	105·0
13	29·365	30·141	C.	C.B.	40·4	47·4	35·4	101·1
14	29·433	30·006	D.	R.	41·6	47·0	39·0	68·0
15	29·648	30·225	C.	F.O.	40·5	48 1	37·5	88·9
16	29·533	30·108	R.	R.	43·8	50·0	41·6	71·7
17	29·526	30·101	B.C.	C.B.	47·1	52·9	40·8	111·3
18	29.756	30 336	C.	C.B.	50·7	57·2	47·3	91·3
19	29·871	30 453	Hz.	C.B.	55·0	61·9	43·6	112·0
20	29·868	30·450	O.	C.	49·1	55·0	45·9	93·7
21	**29·929**	**30·512**	B.C.	B.	46·0	57 8	37·0	108·2
22	29·774	30·354	Hz.	B.C.	49·4	61 0	41 0	103·7
23	29·650	30·228	O.	C	46·4	55·6	43·3	100·9
24	29·656	30·234	B.	B.C.	51·9	62·9	37·5	115·8
25	29·479	30·053	C.	C.	53 9	58·9	41 8	113·0
26	29·479	30·053	C.	C. to B.C.	53·5	60·1	49·4	114·0
27	29·503	30·078	C.	C.B.R.	54·8	**63·3**	48·3	**122·**
28	29·290	29 860	C.B.	B.C. to R.	49·0	54·8	42·1	117·8
29	29·096	29·663	B.C.	B.C.R.	44·4	50·6	38·3	107·0
30	29·289	29·859	C.	C.B.	44·5	49·9	36·9	100·9
Extreme	**29·929**				47·1	**63·3**	33·4	**122·**
Mean, or Sum.	29·096							

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
April 1	...	...	45	325	13·5	3·0	10·5	N.N.W.
2	...	2	30	241	10·0	1·6	*4·10*	N.N.W.
3	0·020	..	...	204	8·5	0·8	6 40	N.N.W.
4	0 015		...	399	16.6	4 0	*6·35*	N.N.W.
5	...	2	15	396	16·5	1·5	8·10	N N W.
6	..	...	30	314	13·1	1·6	10·40	N.W.
7	...	3	25	267	11·1	1·3	*12·20*	N.N.W.
8	...	...	20	188	7·8	...	...	...
9	...	2	50	241	10·0	1·0	*5 20*	W.S.W.
10	0 125	7	25	379	15·8	2·3	*11·55*	W.S.W.
11	**0.320**	3	30	**554**	**23·1**	6·5	*7·35*	W.N.W.
12	0 065	4	40	537	22·4	**17·0**	*4·10*	**N.W.**
13	...	6	35	422	17·6	3·4	9·40	N.N.W.
14	0·225	...	...	163	6·8	...	...	...
15	...	.	55	153	6·4	...	...	...
16	0 295	...	.	335	14·0	3·0	*1·10*	S.S.W.
17	0 020	2	35	324	13·5	2·5	*6 20*	N.N.W.
18	...	1	45	120	5.0	...	...	...
19	..	4	5	202	8·4	.	...	...
20	...	...	15	204	8·5	...	...	...
21	...	**11**	**30**	140	5·8	...	...	...
22	...	6	35	295	12·3	1·0	*4·40*	N.N.W.
23	...	...	55	232	9·7	...	...	...
24	...	9	0	181	7·5	...	...	...
25	...	2	5	241	10·0	...	...	...
26	...	5	10	323	13·9	1·8	*5·20*	W.N.W.
27	0 045	1	55	405	16·9	5·0	*12·40*	W.
28	0 100	7	10	407	17·3	5·0	*3·20*	W.
29	0·105	7	20	346	14·4	5·0	*9·35*	W.N.W.
30	...	2	5	268	11·2	1 0	*2·30*	N.N.W.
Extreme Mean, or Sum.	1·335	98	5	8806	12·2	**17·0**	*4·10*	**N.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at t

NOTE.- B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Ha

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Sola Radi tion Max
May 1	29·642	30 219	C.B.	C.B.	44·1	50·0	36·8	104·
2	29·805	30·386	O.	O.	42·8	50·4	39·3	79·
3	29 882	30 464	O.	C.B.	42·4	53·8	36·2	106·
4	29·881	30·464	Hz.	C.B.	38·7	57·3	36·3	103·
5	29·759	30·340	B.	B.C.	53·4	61·6	42·0	104
6	29·729	30·308	B.C.	B.C.	50·8	61·0	42·0	109·
7	29·810	30·391	H S.	O.	51·1	58·1	42·9	90·
8	29·741	30·320	O.	C. to B.	47·1	60·2	43·9	109·
9	29 674	30·252	O.	C.B. to B	47·5	63·2	44·8	114·
10	29·678	30·256	B.	B.	51·2	65·7	39·9	116
11	29·772	30·352	B.	B.	55·4	70·7	44·3	117·
12	29 857	30·440	B.	B.	58·2	74·8	44·3	117·
13	29·790	30·371	Hz.	B.	46·6	68·7	45·2	109·
14	29·632	30·209	B.	B.	59·0	69·8	46·3	113·
15	29·563	30·140	B.	B.	56·8	64·6	49·3	112·
16	29·648	30·225	O.	O.	48·9	57·6	47·0	89·
17	29·648	30·225	B.	B.	56·4	71·0	49·8	123·
18	29·632	30·209	O.	C.B.	62·0	73·1	55·0	**128·**
19	29·570	30·146	B.	B.C.	54·8	61·7	50·0	114·
20	29·320	29·891	C.R.	B.C.R.	47·3	52·8	42·0	107
21	29·559	30·135	C.	B.C.	47·8	55·7	35 4	108·
22	29·331	29·902	O.	C.	52·4	56·4	45·5	72·
23	29·455	30·029	O.	C.	51·2	61·7	48·9	114·
24	29·828	30·411	C.	C.B.	51·8	57·9	43·8	110·
25	**29·921**	**30·504**	B.	B. to C.	54·4	61·8	41·0	112·
26	29·868	30 450	C.B.	B.C. to C.B.	51·5	59·8	41·3	119·
27	29 752	30·332	B.C.	C.B. to C.	53·2	59·9	46·0	117·
28	29·787	30·367	O.	C. to B.C.	46·3	61·1	45·5	106·
29	29·629	30·206	C.Hz.	C.B.	57·4	67·9	48·6	119·
30	29·617	30·194	O.	C.	52·9	62·8	52·6	106·
31	29·610	30·187	B.	B.	61·0	**75·4**	47·2	127·
Extreme	**29·921**							
Mean, or Sum.	29·320				51·4	**75·4**	35·4	**128·**

NOTE.—Heavy tyve indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time hours.	Direction.
May 1	...	4	5	279	11·6	1·8	9·35	N.N.E.
2	..	...	..	194	8·1	...	...	...
3	...	4	15	205	8·5	...	...	...
4	...	5	55	158	6·6	...	...	
5	...	5	25	244	10·2	0·5	*4·25*	N.
6	...	6	45	346	14·4	1·6	*1·40*	E.N.E.
7	...	..	30	310	12·9	1·0	10·35	E.N.E.
8	...	7	15	371	15·5	2·0	*8·5*	E.N.E.
9	...	8	25	423	17·6	2·0	*1·25*	E.
10	...	11	0	321	13·4	2·0	*3·20*	E.
11	...	**12**	**5**	330	13·7	1·7	*12·25*	E.
12	...	9	35	174	7·3	0·5	*9·20*	N.E.
13	...	6	25	136	5·7	...	...	...
14	.	11	35	257	10·7	0·5	*2·10*	N.N.W.
15	...	4	30	264	11·0	1·0	11·40	N.N.W.
16	...	..	...	126	5·3	..	...	...
17	...	7	20	218	9·1	...	...	...
18	...	2	55	197	8·2	1·0	*6·25*	W.
19	...	5	45	372	15·5	3·0	*10·25*	W.S.W.
20	0·075	4	40	**566**	**23·6**	**10·0**	8·40	**N.W.**
21	...	6	0	315	13·0	1·4	11·20	N.W.
22	**0·140**	..	...	338	14·1	1·0	9·20	N.W.
23	...	.	20	390	16·2	2·5	*10·50*	N.W.
24	...	1	15	242	10·1	1·0	12·30	N.N.W.
25	...	4	30	149	6·2	0·7	*8·10*	E.
26	...	5	30	368	15·3	1·7	*3·30*	N.E.
27	...	2	55	398	16·6	1·4	*2·25*	E.N.E.
28	...	5	30	245	10·2	...	...	...
29	...	7	10	383	16·0	3·0	*6·10*	N.N.W.
30	...	...	50	131	5·5	...	...	...
31	...	11	20	132	5·5	...	...	...
Extreme Mean or Sum.	0·215	163	45	8582	11·5	**10·0**	8·40	**N.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896.	Corrected to Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
June 1	29·402	29·975	B.Hz.	B.C. to B.	59·1	74·9	46·2	117·6
2	29·179	29·747	C.B.	B.C. to C.	63·4	74·2	50·1	128·9
3	29·186	29·754	B.C.	B.C.	62·1	74·4	56·4	132·2
4	29·285	29·855	Hz.	C.	63·8	71·4	56·1	103·9
5	29·245	29·814	B.C.	B.C.	58·0	66·0	52·8	126·9
6	29·216	29·785	C.B.	B.C.	59·1	67·0	49·2	128·2
7	29·017	29·582	C.	R.	57·1	60·0	50·0	120·0
8	28·992	29·556	C.B.	B.C.	57·4	67·4	51·3	129·0
9	28·997	29·561	R.	C.	56·0	68·8	52·9	122·3
10	28·977	29·541	C.	C.	58.7	68·6	56·1	103·9
11	29·273	29·843	O.	C.	58·6	68·0	56·4	98·8
12	29·537	30·112	C.B.	B.C.	64·1	74·1	52·3	130·3
13	29·530	30·105	B.C.	B.C. to C.B.	63·2	74·3	53·0	130·1
14	29·550	30·125	B.C.Hz.	B.	68·6	74·4	58·6	122·9
15	29·456	30·030	B.C.Hz.	B.	62·5	80·1	55·6	128·7
16	29·186	29·754	B.	B. to C.R.	75·3	**81·0**	62·1	**133·**
17	29·071	29·637	R.	R. to C.B.	60·0	67·0	57·8	114·4
18	29·480	30·054	B.	B.C.	57·2	68·5	50·4	123·8
19	29·622	30·199	B.C.	B.C.	60·2	69·8	51·1	126·0
20	29·613	30·190	C.	C.B.	59·7	68·6	50·2	123·3
21	29·616	30·193	C.B.	C.B.	57·6	65·0	50·0	123·3
22	29·635	30·212	C.	C.B. to C.	58·7	67·9	46·8	102·2
23	29·520	30·095	R.	R. to C.B.	55·8	69·1	53·9	123·3
24	29·451	30·025	O.	C.R.	59·4	64·0	54·6	103·8
25	29·467	30·041	C.B.	C.	56·8	63·6	53·0	115·2
26	29·637	30·214	O.	C.	52·4	66·1	48·0	102·2
27	29·609	30·186	B.C.	C.B. to C.	61·4	73·2	50·2	114·4
28	29·509	30·084	C.	C.B.	61·1	65·9	56·2	124·8
29	**29·675**	**30·253**	C.	B.C.	56·3	65·8	49·4	120·9
30	29·406	29·979	R.	C.R.	58·0	61·7	53·0	115·1
Extreme Mean, or Sum.	**29·675** 28·977				60·0	**81·0**	46·2	**133·**

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Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
June 1	...	9	45	157	6·5	...	..	...
2	0·015	6	45	159	6·6	...	...	...
3	...	6	15	142	5·9	...	..	...
4	0·140	...	45	153	6·4	...		...
5	...	7	30	268	11·2	1·2	*3·5*	S.W.
6	0·005	7	50	230	9·6	1·5	*2·30*	S.
7	0·335	2	20	226	9·4	1·2	*5·25*	S.
8	...	7	30	202	8·4	1·0	6·25	S.
9	**0·410**	1	20	272	11·3	1·0	9·40	N.E
10	...	1	40	439	18·3	3·8	*4·50*	N N.W.
11	0·030	...	20	227	9·5	...	...	...
12	..	7	20	160	6·7	...	. .	...
13	...	7	40	157	6·5	..	..	...
14	...	**12**	**30**	232	9·7	0·6	*2·10*	E.
15	...	10	30	191	8·0	1·0	*1·35*	E
16	0·035	7	10	158	6·6	1·2	*4·5*	N.N W.
17	0·335	2	25	358	14·9	2·5	10·30	S.
18	...	9	40	224	9·3	.	...	...
19	...	11	5	288	12·0	1·0	8·30	W.S.W.
20	0·030	5	40	375	15·6	3·5	*2·25*	W.
21	...	6	5	312	13·0	1·2	*3·10*	N.W.
22		4	0	163	6·8	...	...	...
23	0·260	1	50	240	10·0	1·5	*4·0*	W.S.W.
24	0·125	...	25	192	8·0	1·0	*9·35*	N.N.W.
25	0·010	...	40	283	11·8	1·0	11·35	N.E.
26	...	1	0	135	5·6	...	...	...
27	...	2	0	170	7·1	...	...	...
28	...	4	55	357	14·9	3·0	*7·35*	N.N.W.
29	...	6	5	318	13·2	2·0	*1·0*	W.N.W.
30	0·185	2	55	**459**	**19·1**	**7·0**	*1·40*	**W.N.W.**
Extreme Mean, or Sum.	1·915	155	55	7247	10·0	**7·0**	*1·40* Ital. = P.M.	**W.N.W.**

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Temperature.	Corrected to Sea Level	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
July 1	29 397	29·969	R.	R. to C.B.	51·9	58 9	50 0	95·4
2	29·429	30·002	O.	C.	52·4	58·7	48·0	84·8
3	29·325	29·896	C.	B.C.R.	62·8	71·5	54·0	129·1
4	29·426	29 999	C.	C.B.	57·6	69·9	52·1	123·8
5	29·586	30·162	B.C.	B.	57·4	74·2	50·4	119·8
6	29·566	30·142	B.	B.	63·3	79·6	51·9	130 3
7	29·354	29·926	C.	C.B. to C.&R	68·2	73·9	57 6	129·3
8	29·325	29·896	F.	C.	58·1	70·9	55·0	114·7
9	29 324	29·895	C.	C.	62·0	71 8	57·4	126·6
10	29·505	30·080	O	C.	57·9	63·4	56·6	96·8
11	**29·727**	**30·306**	B.C.	B.	57·6	71 7	50·5	124·9
12	29·666	30·244	B.Hz.	B to C.	64·5	81·0	52·2	127·9
13	29 655	30·234	B.C.Hz	B.C.	66·8	81·2	57·4	125·3
14	29·485	30 059	B.C.	C.	65·7	74·1	59·2	130 5
15	29·462	30·036	C.	B.C. to C.	61·3	67·5	55·6	118·3
16	29·637	30 214	C.	C.	55·9	60·2	49 0	96 0
17	29 722	30 301	C.	C.B.	53·0	65·7	47·5	111·3
18	29·696	30·274	C.	C.B.	59·8	71 4	49·2	122·0
19	29·662	30·240	B.C.	C.	64·1	71·7	60·6	116·8
20	29·496	30·070	B.	B.C. to C.B.	67·3	**81·7**	56·1	**133·9**
21	29·302	29·873	C.B.	B. to C. to R.	70·6	78·3	57·9	129·0
22	29 395	29·967	B.C.	C.B.	58·2	65·1	49·4	121 4
23	29·452	30·026	B.C.	C.B.	59·5	67·9	49·6	126·3
24	29·329	29·900	R.	B.C. to C.B	62·7	73 0	51 3	129·0
25	29·188	29·756	B.C.	R. to C	58·5	62·4	56·0	87·1
26	29·140	29·707	C.B.	C.B.TH to R.	64·3	66·2	54·6	121·1
27	29·382	29·954	B.C.	B.C.	55·8	61·7	48·4	117·1
28	29·606	30·183	C.	B.C.	56 6	65·2	45·8	102 0
29	29·362	29·934	C.	C.B to C. to R	59·0	64·1	47·8	118·2
30	29·241	29·810	C.B.Hz.	C.B.	59·8	69·9	55 8	126·9
31	29 384	29·956			62·0	68·3	56·4	117·2
Extreme Mean, or Sum.	**29 727** 29·140				60·5	**81·7**	45·8	**133·9**

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Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREMEPRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
July 1	0·095	1	30	410	17·1	3·0	*6·30*	N.W.
2	0·030	...	...	199	8·3	...	...	...
3	0·075	5	5	281	11·7	2·5	*3·35*	W.
4	...	4	10	**464**	**19·3**	**7·0**	*1 55*	**W.S.W.**
5	...	**12**	**50**	260	10·8	2·0	7·25	W.N.W.
6	...	12	20	199	8·3	...	...	...
7	0·255	4	50	163	6·8	...	...	...
8	...	...	55	188	7·8	1·5	*8·20*	S.S.W.
9	0·030	1	45	364	15·2	2·0	*6 35*	S.S.W.
10	0·065	...	...	316	13·1	1·2	6·35	N.W.
11	...	10	0	*a*139	5·8	...	...	..
12	...	9	10	155	6·5	...	...	...
13	...	6	50	125	5·2	...	...	...
14	...	2	35	180	7·5	...	...	...
15	...	8	55	256	10·7	...	...	...
16	...	...	20	254	10 6	...	...	...
17	...	1	45	170	7·1	...	...	...
18	...	4	40	*a*207	8·6	...	...	...
19	...	...	20	161	6·7	...	...	...
20	...	8	45	149	6·2	...	...	...
21	0·045	8	50	264	11·0	1·5	*8·25*	N.N.W.
22	...	2	15	316	13·2	1·6	*5·5*	W.N.W.
23	...	4	0	272	11·3	1·6	*12·30*	S.W.
24	...	8	0	287	12·0	3·3	11·10	S.W.
25	0·220	...	...	384	16·0	4·5	11·15	S.
26	**0·378**	2	25	261	10·9	...	...	...
27	...	6	50	332	13·8	1·5	*5·25*	N.N.W.
28	...	7	0	186	7·7	...	...	...
29	0·035	3	5	276	11·5	2·2	9 55	S.S.W.
30	0·010	2	15	192	8·0	1·0	*7·25*	E.
31	0·020	3	55	242	10·1	1·0	9·35	E N.E.
Extreme Mean, or Sum.	1·250	145	0	7652	10·3	**7 0**	*1·55*	**W.S.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

a.—From 11th to 18th the Anemometer was under repair ; the velocity was estimated from personal observations.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation Max.
Aug. 1	29·438	30·011	B.Hz.	C. to R.	58·1	68·9	53·3	115·9
2	29 551	30·127	C.	O.	55.9	64·1	55·0	114·1
3	29·490	30·064	O.	C.	55·2	70·0	52·1	122·5
4	29·429	30·002	O.	C.B.	55·1	63·9	49·1	118·9
5	29·551	30·127	O.	C.	51·6	60·7	45·3	112·9
6	29·641	30·218	O.	C.B.	54·9	64·0	48·3	114·0
7	29·544	30·119	C B.	O.	55·9	58·8	50·0	110·0
8	29·505	30·080	O.	C.	54·6	63·8	52·0	113·5
9	29·574	30·150	O.	C.	52.7	57·9	50·4	109·1
10	29·671	30·249	O.	C.	56·2	66 9	51·4	120·9
11	**29·695**	**30·273**	C.	C.	58 1	66 1	49·0	105·3
12	29 691	30·269	C.	C.	59·8	70·3	57·0	111·0
13	29·532	30 107	C.B.	B.C. to C.	64·3	**70·6**	56 2	**127·9**
14	29·370	29·942	C.B.	C.B	57·0	64·5	56·0	124·0
15	29·416	29·989	C.B.	C.B	54·2	64·8	52·0	107·0
16	29 574	30·150	C.B.	B.C.	54·6	63·8	47·7	119·8
17	29·573	30·149	O.	BC.toC.toR	54·2	69·8	48·4	121·7
18	29 436	30·009	O.	C.	55·7	66·3	54 3	113·0
19	29·300	29·871	O.	R.	54·8	57·8	48·0	82·4
20	29·381	29·952	M.	C.	49·6	66 9	46·4	110·0
21	29·279	29 849	C.B.	R. to C.B.	60·4	62·0	54 4	109·0
22	29·552	30·128	C.	C. to C.B.	54·8	64·3	51 5	117·0
23	29·560	30·136	O.	C.	60·8	67·3	56 4	120·7
24	29·316	29·887	O.	R. to C.B.	62·2	66·6	59·4	116·0
25	29·251	29 821	C.B.	C.B. to R.	56·3	63·9	49·4	121·0
26	29 067	29·633	C.B.	B.C. to R.	51 8	56·6	43 9	113·3
27	29·381	29·953	B.C.	B.C. to R.	52·6	58 3	43·8	106·4
28	29·619	30·196	O.	C.B.	51·8	59·9	49·1	105·3
29	29 556	30·132	C.	C.	56·8	62·0	49·6	113·3
30	29·277	29·847	R.	R.	54·4	57·1	52 0	75·1
31	29·344	29·915	O.	R.	52·0	57·7	50·0	71·3
Extreme	**29·695**				55·7	**70·6**	43·8	**127·9**
Mean, or Sum.	29·067							

NOTE —Heavy type indicates maximum or in large quantities ;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours	Direction.
Aug. 1	0 025	2	10	134	5·6	...	..	...
2	..	...	30	205	8·5		...	...
3	...	1	50	219	9·1	1·0	*5·40*	N.N.W.
4	...	4	5	288	12·0	1·0	*12·30*	N.N.W.
5	...	1	20	232	9·7	1 0	*4 20*	N.N.E.
6	...	5	15	253	10 5	1·0	*6·30*	N N.W.
7	0·005	...	45	357	14·9	2·0	8·35	N.N.W.
8	0·040	1	25	250	10·4	1·5	*6·25*	N.E.
9	0·005	...	10	368	15·3	1·5	*1·40*	N.N.E
10	...	1	40	320	13 3	1 0	8 30	N.E.
11	...	1	10	280	11 7	1·5	*4·50*	N W.
12	...	...	50	315	13·1	2 0	9·25	N W.
13	...	6	0	**407**	**17·0**	3·0	*5·20*	W.N.W.
14	...	3	0	354	14·7	2·0	*2·30*	N W.
15	...	3	0	394	16·4	**4·5**	7·20	**N.W.**
16	...	**8**	**20**	346	14·4	2·0	*1·10*	N.W.
17	0·050	6	30	164	6·8	..	...	...
18	0·100	1	5	200	8·3	...		...
19	0·140.	...	10	164	6·8	...	..	...
20	...	1	50	157	6 5	...	.	...
21	0 150	2	40	285	11·9	2 5	*4·25*	N.N.W.
22	...	2	5	292	12·2	1 3	1 55	N.W.
23	..	...	15	262	10·9	1·0	*2 35*	W.N.W.
24	0·240	..	55	356	14·8	3·5	8 55	W.S.W.
25	0·205	5	5	252	10·5	1·2	*2·35*	W.N.W.
26	0·085	7	15	280	11·7	1·2	11·10	W.
27	0·195	4	35	275	11·5	1·0	*12·5*	N.N.W.
28	...	2	55	233	9·7	1·0	*5 55*	W.
29	...		55	345	14·4	2·2	*1 10*	S.W.
30	**0·380**	...	...	337	14·0	2·2	10·40	S.
31	0·125	...	...	152	6·3	...	...	...
Extreme Mean, or Sum.	1·745	77	45	8476	11·4	**4·5**	7.20	**N.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m	Highest.	Lowest.	Solar Radiation Max.
Sep. 1	29·366	29·938	O.	C. to C.B.	54·8	63·6	53·0	99·5
2	29·267	29·837	O.	O.	53 2	57 3	52·6	68·9
3	29·274	29·844	O.	C. to C.B.	53 0	61·7	52 4	91·9
4	29·259	29·829	R.	C.R.	58·7	59·0	54·5	77·3
5	29·130	29·697	O.	R.	57 3	58·7	55·1	65·4
6	29·425	29·998	O.	O.	53·0	56·8	52·0	67·4
7	29·511	30·086	O.	O.	53 8	60·7	52·3	83·0
8	29·345	29·916	O.	O.	56·5	61·8	55·9	75·7
9	29·030	29·595	O.	T.&R.to C.B.	59·7	65·0	56·9	118·1
10	29·073	29·639	O.	C.B.	57·1	**65·8**	54·4	121·7
11	29·152	29·720	C.	C.B.to T.to C.	59·4	62·1	53·6	107·8
12	29·128	29·695	C.	R.Th.	57·5	62·8	51·4	105·8
13	28·696	29·256	C.B.	C.B.R.	57·5	63 8	53·1	**122·9**
14	28·849	29·410	C.B.	C.B.to C.R.	57·4	61·5	50·9	95·9
15	29·262	29·832	B.	B.C. to R.	56·3	65·6	47·6	114·9
16	29·386	29·958	B.C.	C.B.	56·9	63 8	47·4	118·4
17	29·458	30·032	C.	C.R.	55·5	58·5	52 3	85·1
18	29·174	29·742	C.	C.R.	52·4	57·8	48 9	87·8
19	29·163	29·731	B.C.	B.C.	52·5	59·0	44·2	115·0
20	29·097	29·663	C.B.	B.C.R.	49·4	55·5	43·0	110·7
21	29·213	29·782	C.	C.B. to R.	46·8	56·3	40·2	103·9
22	28·700	29·259	R.	R.	53·0	61 4	47·1	111·4
23	28·803	29·374	C.B.	C.B.	52 1	56·3	48 3	106·2
24	29·281	29·851	B.	B.C. to C.	50·5	56 9	44·3	113·0
25	28·164	28·712	C.	R.	53·5	57 1	48·8	81·4
26	29·218	29·787	O.	C.	47·7	55·7	46·8	81·3
27	29·068	29·634	C.	C.B R.	57·6	64·8	48 0	106 0
28	29·283	29·853	B.	B C.R.	49·4	53·6	42·4	113 0
29	29·449	30·022	B.C.	C.B. to C.	48 5	54·3	42·0	105·3
30	**29·856**	**30·438**	C.B.	C B.	47·5	57·1	44·8	99·0
Extreme Mean, or Sum.	**29·856** 28·164				53·9	**65·8**	40·2	**122·9**

NOTE.—Heavy type indicates maximum or in large quantities;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Sep. 1	...	2	0	302	12·6	1·1	*8·35*	N.N.W.
2	...	...	...	257	10·7	1·0	7·40	N.W.
3	...	...	30	184	7·7	...	...	...
4	0·135	...	...	202	8·4	...	..	...
5	0·680	...	...	367	15·3	1·5	*3·20*	N.E.
6	..	...	...	208	8·7	1·0	1·25	N.N.E.
7	...	...	10	213	8·9		...	
8	0·020	...	..	312	13·0	0·6	*6·35*	E.
9	0·675	1	35	301	12·5	2·5	*2·40*	S.
10	0·025	3	5	144	6·0	...	...	...
11	0·200	2	10	160	6·7	..	...	...
12	0·115	...	30	243	10·1	1·5	*12·4*	S.
13	0·195	3	10	256	10·7	1·2	10·30	S.S.W.
14	0·025	2	20	404	16·8	4·0	*4·25*	S.S.W.
15	0·060	6	55	298	12·4	...	...	...
16	0·015	5	35	383	16·0	4·1	*1·35*	W.
17	0·195	...	...	459	19·1	5·3	*6·35*	S.W.
18	0·080	...	35	276	11·5	1·8	*10·30*	W.N.W.
19	...	**9**	**20**	366	15·2	3·0	*1·30*	W.
20	0·110	5	30	276	11·5	0·5	10·35	N.N.W.
21	0·300	3	0	245	10·2	1·9	*3·55*	S.
22	0·130	.	20	515	21·5	7·0	*3·55*	W.S.W.
23	0·160	4	0	654	27·2	8·3	*1·25*	W·N.W.
24	0·030	6	15	378	15·7	1·5	10·10	W.N.W.
25	**0·915**	...	...	**682**	**28·4**	**15·0**	*2·10*	**N.N.W.**
26	0·040	..	...	329	13·7	2·0	11·40	S.S.W.
27	0·165	1	5	474	19·7	9·0	*12·5*	S.W.
28	0·055	7	55	407	17·0	3·8	*1·35*	W.N.W.
29	0·020	1	35	208	8·7	0·6	9·40	S.S.W.
30	...	1	55	128	5·3	...	...	...
Extreme Mean, or Sum.	4·345	69	30	9631	13·4	**15·0**	*2·10*	**N.N.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE,			
1896.	Corrected for Temperature	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a m	Highest.	Lowest.	Solar Radiation. Max.
Oct. 1	**29·870**	**30·461**	O.	C.B.R.	51·3	**58·5**	45 8	109·3
2	29·554	30·130	O.	C.	53 2	56·8	50·6	78·2
3	29·391	29·963	C.	C.	53·2	55·5	53·1	91·0
4	28·924	29·487	R.	R.	56·4	57 8	41·7	92·3
5	28·906	29·469	B.	B.C.R.H.	44 8	50·8	39·4	**113·9**
6	29·075	29·641	R.	R.	44·1	54·9	40·6	60 8
7	29·201	29·770	C.	C. to R.	43·6	57·0	38·3	69 2
8	28·789	29·349	C.B.	C.B. to R.	55·4	**58·5**	47·6	107·3
9	29·158	29·726	B.C	B.C.	50·9	58·2	45·2	107·8
10	29·120	29·687	C.	C. to C.B.	49·3	56·5	44·4	103 0
11	29·182	29·750	O.	C.	35·0	46·1	34·0	74·0
12	29·324	29·895	C.	C.	38·6	46·8	33 8	89 6
13	29·664	30·242	B.	C.B.	36·4	47·8	32·9	92·2
14	29·753	30·332	R.	R. to C.B.	45·5	54·4	38·0	96·0
15	29·594	30·170	R.	C.R.	49·3	50·6	47·0	53·4
16	29·455	30·029	D.	R.	49·1	49·9	45·2	50·0
17	29·322	29·893	D.	O.	44·9	48·2	44·4	66·0
18	28·777	29·337	C.B.	C.B.	38 9	46·4	34·9	87·1
19	28·572	29·128	O.	R. to C.	36·2	40 0	33·6	54·0
20	28·727	29·286	C.	C.	37·3	46·2	33·6	72·5
21	28·853	29·415	F.	C.	35·0	46·4	31·4	64·8
22	29·132	29·699	C.	C.B.	36·4	43 5	33·0	74 2
23	29·382	29·954	B.Hz.	C.	34·4	45·7	32·0	90 7
24	28·972	29·536	D.	R.	43·1	50·7	33·9	90·4
25	28·633	29·190	C.	C.B.R.	37·8	42·7	33·8	89·3
26	28 862	29·424	B.	C.B.	39·8	47·8	34·2	97·8
27	29·114	29·681	B.C.	B.C.	34·9	47·1	33 4	89 0
28	29·184	29·752	B F.	C.B.	30 7	45·0	29·1	75·0
29	28·996	29·562	F.	F. to O.	31·2	38·8	29 3	53 3
30	29 242	29·811	Hz.	C.	39·4	45·7	37·4	69 6
31	29·162	29·730	B.	C.B.	36·0	42·6	30·7	69 0
Extreme Mean, or Sum.	**29·879** 28·572				42·3	**58·5**	29·1	113·

NOTE. – Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896.	Inches.	Hours.	Minutes	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Oct. 1	0·080	1	20	141	5 9	...	...	...
2	...	...	...	230	9·6	...	...	...
3	0·015	...	20	194	8 1	...	...	...
4	0·275	...	...	414	17·2	3·5	9·25	S.S.W.
5	0·140	6	40	408	17·0	6·5	11·55	W.
6	0·225	...	...	440	18 3	8 0	*4·40*	S S.W.
7	0·110	...	20	371	15·5	9·0	*11·35*	S.S.W.
8	0·110	4	25	**730**	**30·4**	**10·5**	9·55	**S.S.W.**
9	...	**8**	**5**	367	15·3	3·6	11·45	S.W.
10	0·165	1	40	286	11 9	3·5	*11 55*	N N.W.
11	0 055	...	20	434	18 1	3·0	2·20	N.N.W.
12	0·075	1	0	480	20 0	3·5	*12·40*	N.N.E.
13	...	4	50	434	18·1	2 2	11·25	N.N.E.
14	**0·320**	1	15	384	15·2	2·1	*1 30*	E.N.E.
15	0 095	...	...	419	17·5	2 0	11·50	N.E.
16	0·290	...	...	622	25·9	7·0	*3·5*	N.E.
17	0 030	.	...	339	13·8	1 5	1·30	N.N.E.
18	0·065	2	50	396	16·5	3 0	2 25	N.W.
19	0 150	...	...	231	10·0	...	...	...
20	...	1	5	311	13 0	0·5	4·0	N.N.W.
21	...	...	...	162	6·7	...	...	...
22	0·010	3	35	293	12·2	...	...	...
23	...	1	10	159	6·6	...	...	...
24	0·140	...	40	383	16·0	4·0	7·30	S.S.W.
25	0·150	3	10	331	13 8	2·5	*1·20*	W.
26	...	5	10	337	14·0	2·3	*12 20*	W.
27	...	6	40	149	6 2	...	...	...
28	...	3	0	118	4·9	...	...	...
29	. .	...	...	147	6·1	...	...	...
30	...	.	10	281	11 7	0·6	*2 25*	E.N.E.
31	...	3	30	262	10·9	...	...	...
Extreme Mean, or Sum.	2·500	61	15	10254	13·8	**10·5**	9·55	**S.S.W.**

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE. – B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation, Max.
Nov. 1	29·207	29 776	O.	O.	40·5	47·1	36·0	58·1
2	29 364	29·936	C.B.	C.	40·4	45·7	36·3	79·8
3	29·415	29·988	C.	C.	36·3	42·6	35·5	65·9
4	29·762	30·342	B.Hz.	B.Hz.	34·1	44·7	30·5	63·7
5	29·966	30·550	B.Hz.	B.Hz.	35·2	45·1	33 1	67·0
6	29 838	30 419	B.F.	B.Hz.	31·0	42·4	26·6	63·8
7	29 414	29 987	C.	C. to R.	34·2	42·3	31·2	49·6
8	29 239	29·809	C.	B.C.	35·8	44·2	32.8	68 2
9	29·742	30·321	B.Hz.	B.C.	31·8	41·0	30·2	62 8
10	29 795	30·375	C.	C.B.	36·0	44·8	34 0	70·4
11	29·614	30·191	C.	C.	45·0	**48·9**	40·4	66·3
12	29·469	30·043	C.	C.	43·7	46·9	41·4	63·2
13	29·295	29·865	C.	C.B.	36·9	44·6	35·0	73·7
14	29·187	29·755	F.	C. to R.	34·7	43·3	32·2	68·6
15	28·780	29·340	B.	B.C.toC.toR	39·0	45·2	37·2	**86·2**
16	29 270	29·840	O.	C.	40·3	45·0	35·0	64·7
17	29·517	30·092	O.	O.	38·2	41·0	36·8	42·8
18	29 298	29·868	O	C.R.	37 4	45·0	35·0	48·5
19	29·504	30·079	B.C.	B.C.	37·4	43·8	33·3	80·8
20	29 456	30·030	B.	C.B.	42·1	46·8	39·2	80·3
21	29 868	30·450	C.	C.	42·7	47·6	37 0	52 1
22	29 977	30·561	C.	O.	44·2	46·7	43·8	57·3
23	29 980	30·564	O.	O.	44·0	45 0	42·7	50 8
24	**30 022**	30·607	O.Dark.	O.D.	43 4	44·1	38·1	43·0
25	30 005	30·590	O.	O.	37·0	40·2	36 9	42·0
26	29 842	30·423	O.	O.	39·0	40·8	38·0	44·2
27	29·633	30·210	O.	O.	38·6	43·1	37·6	64 7
28	29·430	30·003	O.	O.	33·8	43·5	32·6	43·6
29	29·736	30·315	B.	B.	32·6	38·0	30 2	62·1
30	29 767	30·384	B.Hz.		27·4	37 0	26·0	62 9
Extreme Mean, or Sum.	**30·022** 28·780				37·7	**48·9**	26·0	**86·2**

NOTE.—Heavy type indicates maximum or in large quantities ;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Nov. 1	0·040	...	...	306	12 7	...	...	...
2	...	1	45	299	12·5	1·2	9·30	N.N.E.
3	...	...	...	275	11·5	...	...	..
4	...	* ...	...	150	6·2	...	...	...
5	...	* ...	...	207	8·6	...	.	..
6	...	* ...	5	152	6·3	...		...
7	0·240	..	...	259	10 8	3·0	*11·50*	N.E.
8	0·200	2	10	505	21 0	3·3	*2·40*	N.N.E.
9	...	2	5	304	12·7	1·0	12·20	N.
10	...	1	10	250	10 4	0·5	*3·30*	W.
11	...	...	...	324	13·5	0·6	*12·35*	W.
12	...	...	...	152	6 3	...	..	...
13	0 025	...	50	280	11·7	1·5	11·10	S.S.W.
14	**0·320**	...	30	294	12·2	3·0	*4·20*	S.
15	0·215	4	35	342	14·2	1·0	*12·50*	W.
16	0·095	...	35	219	9·1	...	...	...
17	...	...		170	7·1	...	..	
18	0·065	..	...	267	11.1	0·5	10·50	S.S.W.
19	..	**4**	**50**	265	11·0	1·5	*8·25*	S.W.
20	0 015	3	30	296	12·3	1·0	10·40	W.N.W.
21	...	...	...	249	10·4	1·0	*6·10*	W.N.W.
22	...	...	...	135	5·6	...	...	...
23	...	...	...	127	5·3	...	...	...
24	0 030	...	...	151	6·3	...	...	...
25	...	...	...	360	15·0	1·5	*7·35*	E.N.E.
26	...	...	..	**568**	**23·7**	5·0	*6·20*	E.N.E.
27	...	...	...	540	22·5	**4·5**	11·30	E.N.E.
28	0 015	...	...	555	23·0	3·3	11·25	E.
29	...	* ...	...	488	20·3	4·0	7·5	E.
30	...	2	25	229	9·5	...	...	
Extreme Mean or Sum.	1·260	24	30	8718	12·1	**4·5**	11·30 Ital.=P.M.	E.N.E.

* Sunshine had not sufficient power to mark papers of recorder.

Small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1896.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solor Radia-tion. Max.
Dec. 1	29·382	29·954	B.Hz.	C.	32·2	38·0	29·4	53·0
2	29·071	29·637	D.	R.	35·8	40·4	35·3	40·0
3	28·932	29·495	O.	C. to R.	45·0	47·0	40·1	79·2
4	28·650	29·207	O.	R.	42·0	45·3	40·1	44·9
5	28·333	28·884	C.B.	R. to O.	41·2	43·5	36·0	49·8
6	28·127	28·674	O.	R.	39·5	43·0	36·4	43·0
7	28·602	29·159	R.	C.	39·7	42·1	35·8	49·5
8	29·123	29·690	C.	C.	37·4	44·4	33·2	68·2
9	28·811	29·372	C.	R.	45·2	45·2	41·6	46·6
10	29·268	29·838	O.	R.	39·4	47·7	36·3	52·6
11	29·282	29·852	O.	C.B.	42·8	47·8	38·5	70·1
12	29·209	29·778	O.	R.	38.0	40·4	34·0	44·8
13	29·183	29·751	B.	B.to C. to R.	35·8	40·8	34·8	75·0
14	28·682	29·240	O.	O.	37·5	39·5	36·7	41·0
15	29·129	29·696	O.	O.	36·0	37·3	31·8	47·3
16	29·149	29·716	F.	**F.**	31·6	33·0	28·0	32·3
17	29·035	29·600	C.B.	C.s.	29·8	33·0	26·3	53·0
18	28·949	29·512	O.	O.	31·0	33·7	28·7	38·5
19	29·242	29·811	O.	O.	32·0	34·0	29·8	53·4
20	29·594	30·170	O.	C.	34·0	37·5	32·0	53·0
21	29·571	30·147	O.	O.	32·1	33·7	31·0	36·5
22	29·447	30·020	O.	C.	32·7	38·3	28·8	74·1
23	29·647	30·224	B.	B.	30·6	38·9	29·0	67·3
24	29·521	30·096	C.B.	C to R.	32·8	42·4	27·1	46·0
25	29·611	30·188	B.	B.C. to C.	35·5	42·2	35·2	73·9
26	29·559	30·135	R.	C.	46·1	**51·8**	40·3	53·6
27	**29·734**	30·313	B.	B. to C.	39·8	51·1	38·9	78·3
28	29·160	29·728	R.	R.	47·9	49·9	40·9	63·2
29	**29·734**	30·313	B.C.	C.B.	32·7	42·1	31·0	76·8
30	29.388	39·960	O.	O.	48·4	49·0	40·5	52·6
31	29·416	29·989	C.	C.B.	43·3	49·3	41·9	**79·7**
Extreme	**29·734**				37·7	**51·8**	26·3	**79·7**
Mean, or Sum.	28·127							

NOTE.—Heavy type indicates maximum or in large quantities ;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1896.	Inches.	Hours.	Minutes.	Miles	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Dec. 1	..	...	...	344	14·3	1·5	*1·25*	E.S.E.
2	0·200	...	..	270	11·2	...	...	...
3	0·325	...	20	298	12·4	1·0	*12·25*	S.S.W.
4	0·245	...	...	376	15·7	3·5	*4·25*	E.S.E.
5	0·260	.	..	368	15·3	2·5	*2·20*	W.S.W.
6	0·360	...	...	290	12·1	2·0	3·30	E.S.E.
7	0·060	...	..	463	19·3	**7·0**	*2·20*	**N.W.**
8	0·065	...	50	299	12·5	1·5	*11·30*	S.S.E.
9	0·205	...	...	**576**	**24·0**	5·6	9·50	S.
10	0·115	...	...	366	15·3	2·0	*6·50*	S.
11	...	..	25	244	10·2	.	...	
12	0·270	..	...	340	14·2	2·0	2·0	S.S.W.
13	0·100	2	25	301	12·5	2·0	*11·50*	E.S.E.
14	0·050	...	...	444	18·5	3·0	3·25	E.
15	...	...	...	203	8·5	...	...	...
16	...	...	...	99	4·1	...	...	...
17	*0·010*	...	...	234	9·7	...	...	...
18	...	..	...	268	11·2	...		...
19	*0·020*	..	...	374	15·6	0·5	*4·0*	N.N.W.
20	...	...	. .	192	8·0	...	...	...
21	...	...	...	142	5·9	...	...	. .
22	*0·010*	...	20	156	6.5	...	...	...
23	...	3	25	112	4·7	...	...	...
24	0.315	...	...	376	15·7	2·5	*7·20*	S.S.W.
25	...	3	5	380	15·8	3·0	12·30	N.N.W.
26	0·150	..	...	480	20·0	3·0	*6·40*	W.S.W.
27	0·020	**5**	**30**	375	15·6	3·5	3·30	W.N.W.
28	**0·485**	...		522	21·7	5·5	6·40	S.S.W.
29	0·020	2	10	347	14·5	2·8	*5·55*	S.S.W.
30	...	...	...	555	23·1	6·0	*7·35*	S.W.
31	0·055	1	0	400	16·7	4·0	12·5	W.
Extreme Mean, or Sum.	3·340 Ital. = Melt'd Snow.	19	30	10194	13·7	**7·0**	*2·20* Ital. = P.M.	**N.W.**

small type indicates minimum or in small quantities.

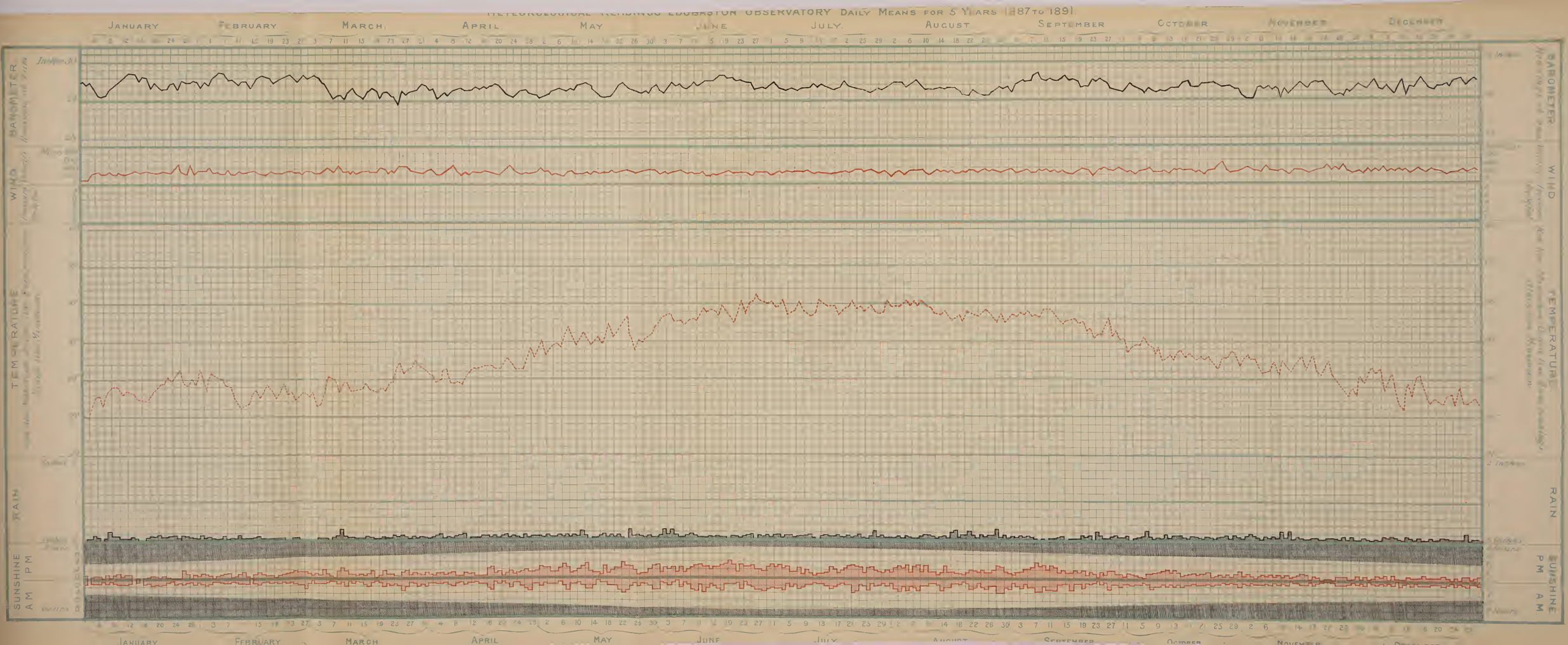
EDGBASTON METEOROLOGICAL OBSERVATORY.

Comparison of Maxima, Minima, and Means for each month of 1896, *with the Average for the same month for the past Nine Years.*

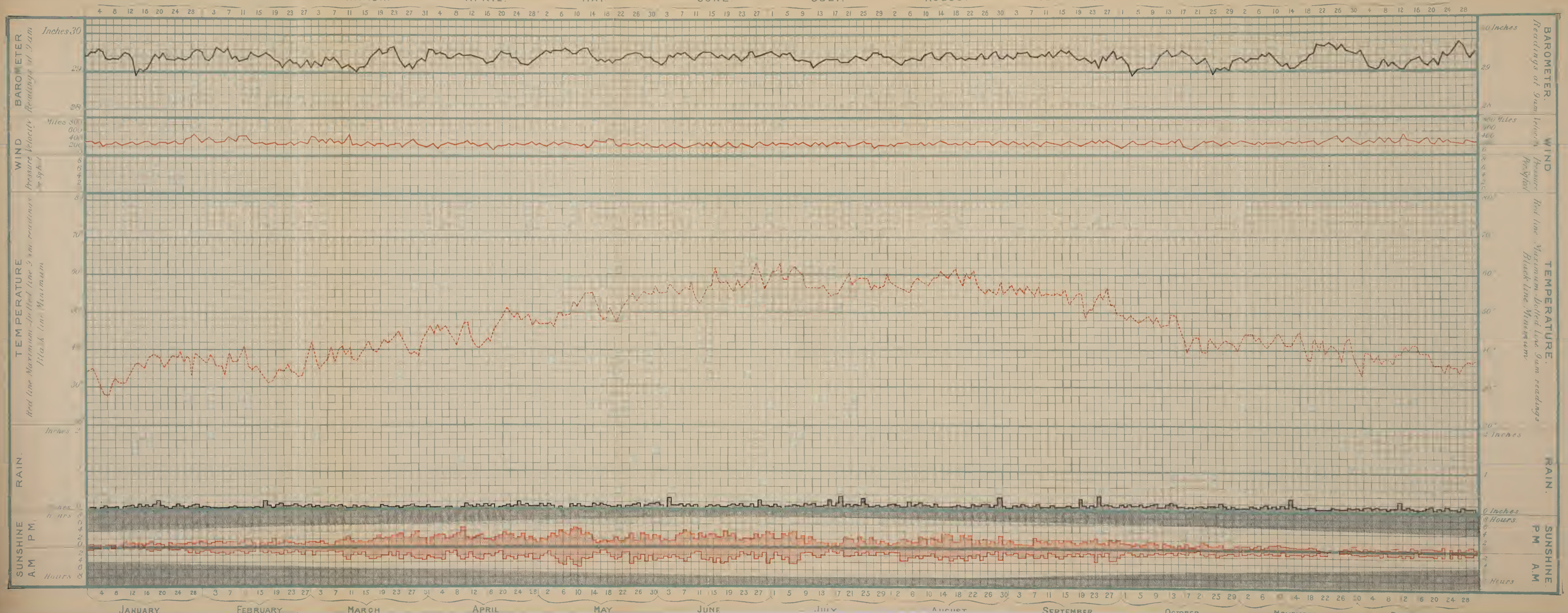
The Large Type is for 1896. The Small Type underneath, the corresponding figure for the past Nine Years.

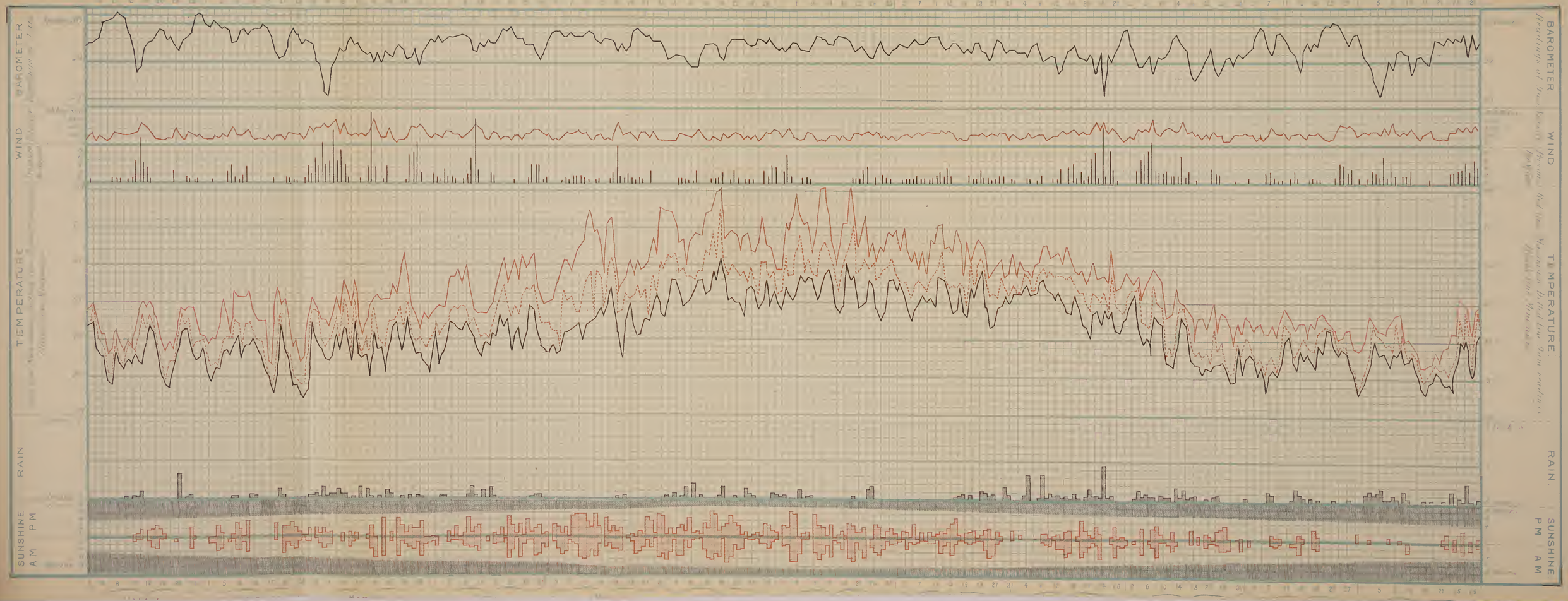
DATE.	BAROMETER.						TEMPERATURE.							SUNSHINE.	RAIN.	WIND.			DATE.
1896.	Mean of 9 a.m. Readings.	Mean corrected to Sea Level.	Highest.	Date of Highest Reading	Lowest.	Date of Lowest Reading.	Mean 9 a.m. Reading.	Maximum.	Date of Maximum.	Minimum	Date of Minimum.	Solar Radiation Maximum.	Date of Solar Radiation Max.	Total Hours and Minutes.	Total Inches.	Total Velocity in Miles.	Extreme Pressure in lbs. per sq. ft.	Date of Extreme Pressure.	1896.
														H. M.					
JANUARY, 1896	29·739	30·318	30·334	9th	28·754	14th	39°·6	50°·8	15th	27°·2	22nd	87°·0	18th	25—40	1·150	8184	12·0	15th	JANUARY, 1896.
Do. Past 9 Years	29·382	29·954	30 120	3rd, 1889	28·004	23rd, 1890	35°·7	58°·0	10th, 1888	10°·8	5th, 1894	86°·6	31st, 1893	38—44	1·794	10125	20·0	26th, 1888	Do. Past 9 Years.
FEBRUARY, 1896 ..	29·728	30·307	30·116	3rd	29·089	20th	37°·6	53°·8	19th	24°·4	26th	100°·2	9th	68—50	0·565	7595	5·0	8th	FEBRUARY, 1896.
Do. Past 9 Years	29·450	30·024	30·126	7th, 1887	28·119	21st, 1893	35°·9	61°·9	28th, 1891	8°·0	6th, 1895	98°·2	27th, 1894	53—39	1·104	9440	27·5	11th, 1894	Do Past 9 Years.
MARCH, 1896	29·199	29·767	29·711	10th	28·139	4th	42°·4	63°·5	24th	29°·8	15th	111°·0	23rd	90—40	2·685	11254	19·5	16th	MARCH, 1896.
Do. Past 9 Years	29·304	29·875	30·041	30th, 1892	28·133	11th, 1888	39°·3	64°·8	29th, 1893	21°·3	4th, 1890	111°·2	31, 1894; 29, 1893	93—42	1·492	10061	37·0	24th, 1895	Do. Past 9 Years.
APRIL, 1896	29·581	30·157	29·929	21st	29·096	29th	47°·1	63°·3	27th	33°·4	2nd	122°·2	27th	98— 5	1·335	8806	17·0	12th	APRIL, 1896.
Do. Past 9 Years	29·342	29·913	30·080	17th, 1887	28·533	4th, 1889	44°·3	79°·0	20th, 1893	27°·9	14th, 1892	125°·7	21st, 1893	114—42	1·638	8924	12·0	1st, 1887	Do. Past 9 Years.
MAY, 1896	29·690	30·268	29·921	25th	29·320	20th	51°·4	75°·4	31st	35°·4	21st	128°·3	18th	163—45	0·215	8582	10·0	20th	MAY, 1896.
Do. Past 9 Years	29·323	29·894	30 015	2nd, 1895	28 656	1st, 1888	51°·1	77°·6	30th, 1895	31°·0	17th, 1891	132°·3	31st, 1892	142 -16	2·109	9300	18·0	20th, 1887	Do. Past 9 Years
JUNE, 1896	29·378	29·949	29·675	29th	28·977	10th	60°·0	81°·0	16th	46°·2	1st	133°·8	16th	155—55	1·915	7247	7·0	30th	JUNE, 1896.
Do. Past 9 Years	29·456	30·030	29·880	24th, 1895	28·663	30th, 1890	57°·2	82·8	16th, 1893	38°·3	1st, 1890	131°·8	10th, 1892	150—48	1·844	7928	6·5	28th, 1893	Do. Past 9 Years.
JULY, 1896 ...	29·459	30·033	29·727	11th	29·140	26th	60°·5	81°·7	20th	45°·8	28th	133°·9	20th	145— 0	1·250	7652	7·0	4th	JULY, 1896.
Do. Past 9 Years	29·352	29·924	29·850	1st, 1889	28·717	1st, 1890	58°·6	84°·6	4th, 1887	39°·5	11th, 1888	138°·0	2nd, 1893	122—43	2·538	8780	11·0	19th, 1892	Do. Past 9 Years.
AUGUST, 1896	29·470	30·044	29·695	11th	29·067	26th	55°·7	70°·6	13th	43°·8	27th	127°·9	13th	77—45	1·745	8476	4·5	15th	AUGUST, 1896.
Do. Past 9 Years	29·327	29·898	29·796	3rd, 1887	28·636	20th, 1889	58°·3	85°·6	18th, 1893	41°·2	14th, 1887	131°·7	18th, 1893	131—56	2·971	8747	12·0	26th, 1891	Do Past 9 Years.
SEPTEMBER, 1896 ..	29·169	29·737	29·856	30th	28·164	25th	53°·9	65°·8	10th	40°·2	21st	122°·9	13th	69—30	4·345	9631	15·0	25th	SEPTEMBER, 1896.
Do. Past 9 Years	29·458	30·032	29·918	24th, 1887	28·494	2nd, 1887	54°·7	81°·8	24th, 1895	33°·0	29th, 1887	129°·0	9th, 1895	116—28	1·715	8023	12·0	1st, 1891	Do. Past 9 Years
OCTOBER, 1896 ..	29·157	29·725	29·879	1st	28·572	19th	42°·3	58°·5	1st & 8th	29°·1	28th	113°·9	5th	61—15	2·500	10254	10·5	8th	OCTOBER, 1896.
Do. Past 9 Years	29·301	29·872	30·096	31st 1891	28·440	25th, 1894	46°·2	70°·0	1st, 1895	27°·9	28th, 1890	112°·0	16th, 1893	72—45	2·680	8969	17·0	7th, 1889	Do. Past 9 Years.
NOVEMBER, 1896	29·579	30·155	30·022	24th	28·780	15th	37°·7	48°·9	11th	26°·0	30th	86°·2	15th	24—30	1·260	8718	5·0	26th	NOVEMBER 1896.
Do. Past 9 Years	29·316	29·887	30·069	5th, 1891	27·813	11th, 1891	42°·5	61°·6	9th, 1889	23°·5	27th, 1890	97°·9	2nd, 1894	38—57	2·462	9718	19·0	24th, 1888	Do. Past 9 Years.
DECEMBER, 1896 ..	29·179	29·747	29·734	27th & 29th	28·127	6th	37°·7	51°·8	26th	26°·3	17th	79°·7	31st	19—30	3·340	10194	7·0	7th	DECEMBER, 1896.
Do. Past 9 Years	29 374	29·946	30·133	30th, 1893	28·208	20th, 1893	37 1	55°·4	6th, 1888	14°·5	22nd, 1890	88°·0	30th, 1895	32—55	2·027	9830	24·0	10th, 1891	Do. Past 9 Years.
THE YEAR 1896 ...	29·444	30·018	30·334	9th Jan.	28·127	6th Dec.	47°·2	81°·7	20th July	24°·4	26th Feb.	133°·9	20th July	1000—25	22·305	106593	19·5	16th March	THE YEAR 1896.
THE PAST 9 YEARS ...	29·364	29·936	30·133	Dec. 30th, 1893	27·813	Nov. 11th, 1891	46°·8	85°·6	Aug. 18th, 1893	8°·0	Feb. 6th, 1895	138°·0	July 2nd, 1893	1109—26	24·385	109839	37·0	Mar. 24th, 1895	THE PAST 9 YEARS.

The Time Scale of the Charts has been reduced to one half the value used in previous Charts in order to present the Records for the whole year on One Sheet.


METEOROLOGICAL READINGS EDGBASTON OBSERVATORY DAILY MEANS FOR 5 YEARS 1887 TO 1891
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
BAROMETER
WIND
TEMPERATURE
RAIN
SUNSHINE
AM
PM

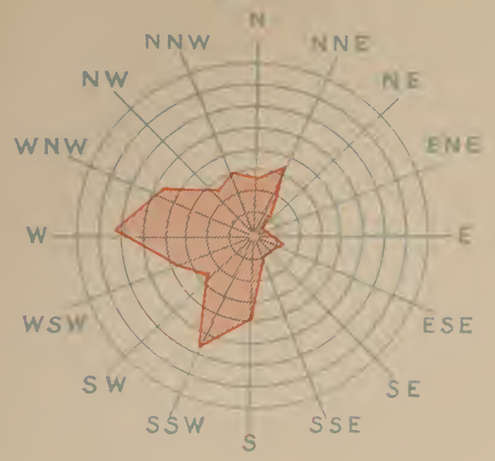
Meteorological Readings Edgbaston Observatory Daily Means for 5 Years 1892 to 1896.

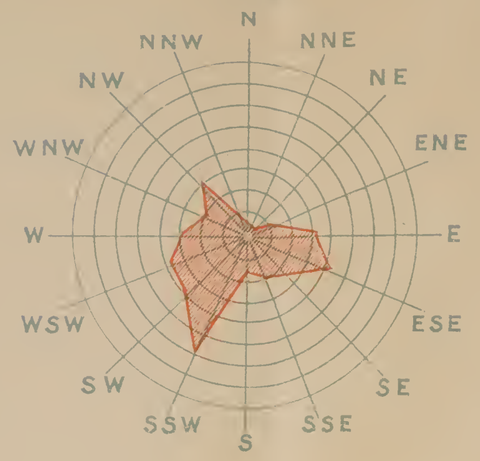


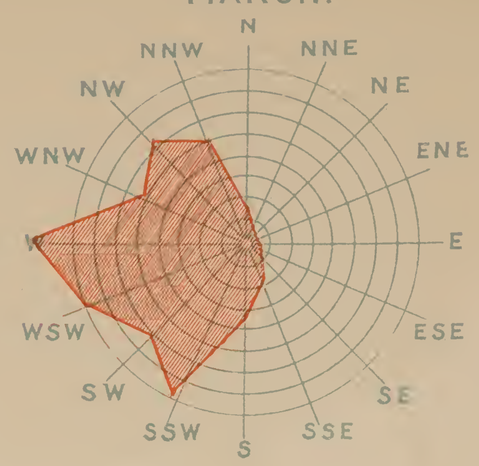

METEOROLOGICAL READINGS EDGBASTON OBSERVATORY FOR 1896.
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER.
OCTOBER
NOVEMBER.
DECEMBER
BAROMETER.
WIND
TEMPERATURE.
RAIN
SUNSHINE
AM PM

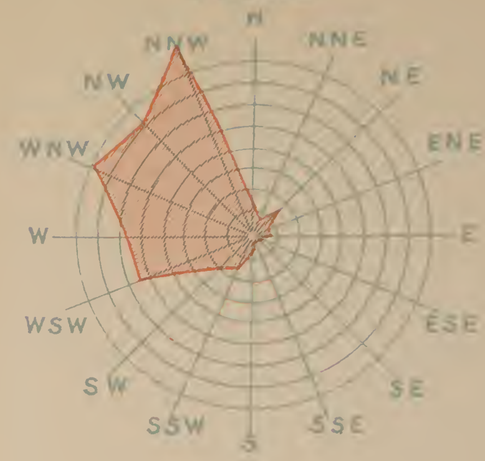
METEOROLOGICAL READINGS, EDGBASTON OBSERVATORY.

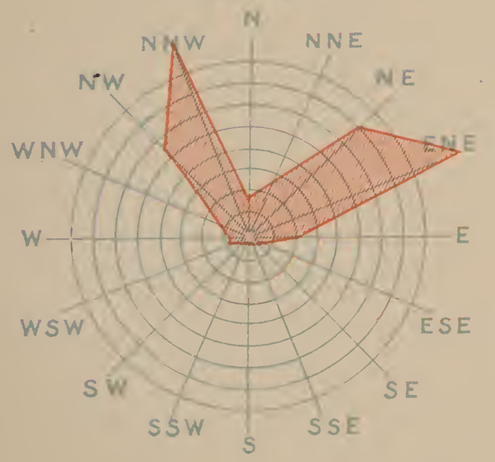
Horizontal Motion of the Air referred to 16 points of the Compass for the Year 1896.

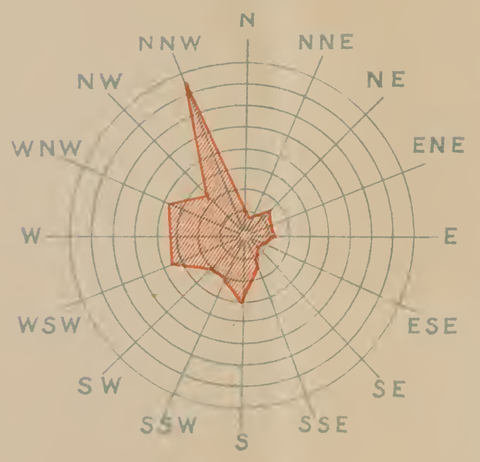


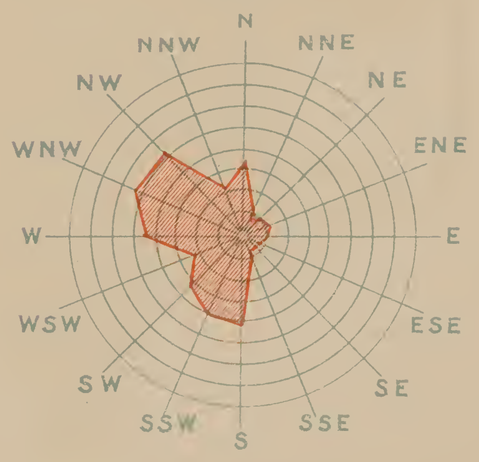


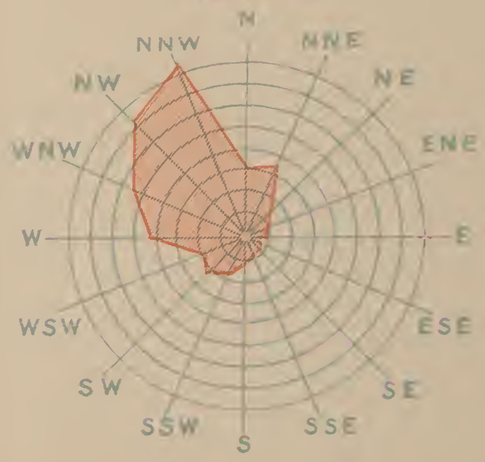


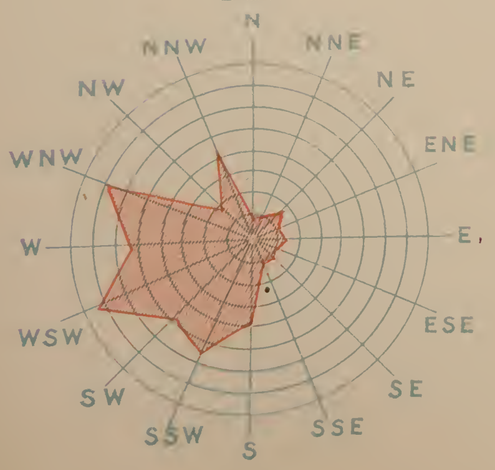


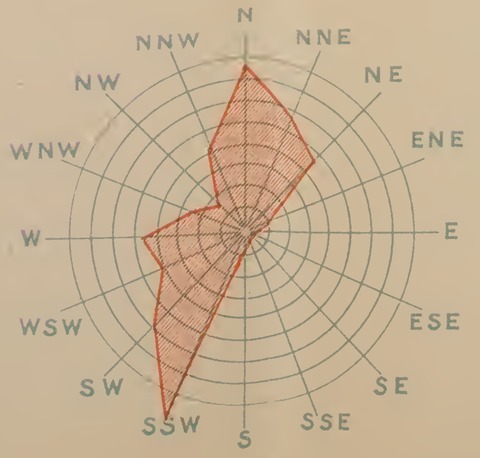


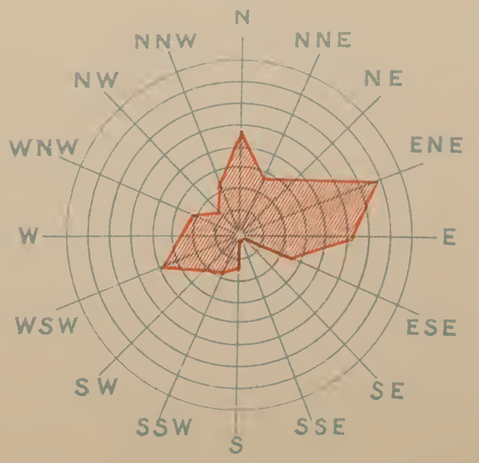


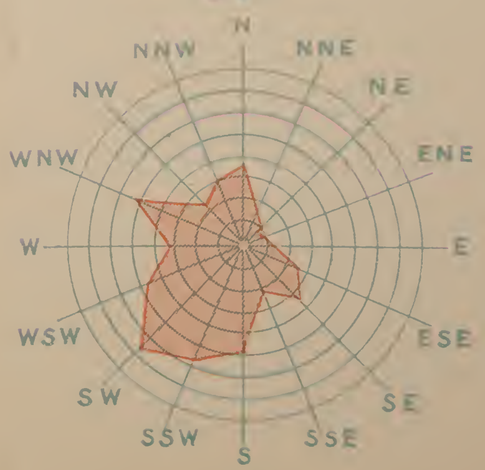












The Centre being Zero, each Concentric Circle represents 200 Miles.

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VOL X.—PART I.

SESSION 1896.

I.—*The Suprarenal Capsules in the Lower Vertebrates.*

BY SWALE VINCENT, M.B. LOND.,

DEMONSTRATOR OF PHYSIOLOGY AND ASSISTANT LECTURER ON HISTOLOGY, MASON COLLEGE, BIRMINGHAM.*

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THE SUPRARENAL BODIES IN FISHES, AND THEIR RELATION TO THE SO-CALLED HEAD-KIDNEY.

[Being an abstract of a Paper read before the Zoological Society of London, November, 19th, 1895, ordered for publication in Trans. Zool. Soc., and at present in the press.]

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* This research has been carried out in the Physiological Laboratory, Mason College, Birmingham.

PART II.

The Suprarenals in Amphibians and Reptiles.

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INTRODUCTORY.

In close relation to the kidney of Mammals is found an organ which has long gone by the name of "suprarenal." Its function has been, until quite recently, wrapped in almost total obscurity, and even now we are far from having arrived at a clear understanding on the subject.

It is only within the last few years that the importance of this organ in Mammals has been definitely ascertained. During this time there has been much careful examination of its minute structure, its chemistry, and its physiology. But among the lower Vertebrates little or nothing has been done in this direction. There is a wide tendency among Zoologists to ignore the "adrenal body" as being merely "vestigial" or "embryonic remains."

It is curious that recent researches on the physiology of the Mammalian suprarenal seem to point out that it is the medulla and not the cortex which is the actively-secreting part of the gland.* This is not what one would have expected, seeing that the cortex has a structure which is so very glandular in appearance.

* Oliver and Schäfer, Proc. Physiological Society, 1895.

I feel sure that the cortex is secretory in some way or other, although at present it would be hazardous to say any more. So far as our present knowledge of its structure can tell us, the suprarenal in Mammals is a double secreting blood gland with a rich sympathetic nerve-supply.

The undoubted importance to life of the organ in Mammals has led me for some time past to devote considerable attention to the corresponding structure (or, more accurately, structures) in the lower classes of Vertebrates.

In *Amphioxus** there appears to be nothing which could be considered as suprarenal. In the Cyclostomes structures have been described which may be suprarenals, but I have been unable to get material, and so must leave the matter open for the present.

In Elasmobranchs we get two distinct structures: one, the interrenal, obviously a secreting gland; the other, the paired suprarenals, of a more doubtful nature but probably also secretory, but bearing a certain curious relationship to the sympathetic nervous system. The presumption is that the former corresponds to the "cortical" part of the suprarenals in Amphibia, Reptilia, Birds, and Mammals, while the latter constitute the "medulla" in these higher classes.

In Ganoids and Teleosts there appears to be only one of these portions represented, viz., the cortical which constitutes the whole suprarenal of these orders.

In Dipnoi, nothing certain is known.

In Amphibians we once more get the two kinds of structure, but here, instead of being separate as in Elasmobranchs, they are united together in the same organ.

Are the so-called "cortex" and "medulla" in Amphibians and higher Vertebrata really the homologues of the interrenal and paired suprarenals respectively of Elasmobranch fishes? There is no difficulty in identifying the interrenal of Elasmobranchs with the "cortical" substance of Amphibians, Reptiles, Birds, and Mammals; but it is not quite so easy to determine that the paired

* See Willey, Amphioxus and the Ancestry of the Vertebrates 1894.

bodies along the sympathetic in Elasmobranchs truly agree with what is called the "medulla" in the higher Vertebrates.

With regard to the true nature and origin of the suprarenals, there is much to support Mihálkovics' view that their "cortical" part is developed from the reproductive gland. Their position is in many cases very suggestive: thus in Reptiles and Birds they are placed in close anatomical relation to the ovary or testis. The origin of the "medulla" is quite uncertain.

As the following work upon Amphibians and Reptiles has been done in the winter, I have only been able to obtain comparatively few species in a fresh condition, but I hope my observations will be of some value if only to call attention to a neglected subject, as preliminary to further researches when opportunity offers.

I have made a point of using only perfectly fresh material for histological work, so that the tissues were examined in most cases in practically a living condition. Some of the structures were examined fresh after embedding in gum and freezing. Others have been hardened, and cut in paraffin after staining in bulk. I have also used other methods as occasion suggested.

I take this opportunity of thanking the Research Committee of the Birmingham Natural History and Philosophical Society for a grant in aid of these researches. My thanks are also due to G. A. Boulenger, Esq., F.R.S., of the Natural History Museum, South Kensington, for his kindness in identifying specimens for me.

PART I.

The Suprarenal Bodies in Fishes and their relation to the so-called Head-kidney.

*** The following is the substance of a paper read at a Meeting of the Zoological Society of London, held on November 19th, 1895.

A.—Gross Anatomy.

My investigations in this department have led me to conclude:

1.—*Suprarenals are almost certainly present in all Elasmobranchii, Holocephala, Ganoidei, and Teleostei, and very probably in Dipnoi also.*

In Elasmobranchii there are two distinct sets of bodies which have borne the name of "suprarenals." One of these is a more or less rod-shaped structure, unpaired as in *Scyllium*, or paired as in *Raja*, which lies in the region of the hinder end of the kidney, nearly in the middle line as a rule in the first case, on the inner and hinder border of the kidney in the second. This is the "interrenal." The other set of structures is a segmentally-arranged series of paired bodies, placed on the intercostal arteries.

The interrenal is "ochre-yellow," and sometimes extends as far forward as the anterior extremity of the kidney. It has a striking general resemblance to the suprarenals of Amphibia and Reptilia. One often finds streaks or dots of the same material in other parts of the kidney, reminding one of the "accessory" bodies in Mammals. The body is thicker behind than in front, but is of irregular calibre. In the Rays the interrenal is never quite symmetrical, and in some of the Sharks the unpaired body is placed on the median surface of one or other kidney.

2.—In Elasmobranchs *the interrenal body is totally distinct and separate from the segmental bodies, and there is no kind of connection between them.*

3.—*There is no "third kind of body"* in relation to the kidneys of Scyllium, as Balfour surmised there might be.

4.—*The yellow bodies scattered in the Sturgeon's kidney are the true suprarenals* in Ganoids, and correspond to the interrenal of Elasmobranchs and the suprarenals of Teleosts.

The suprarenals in the Sturgeon are "ochre-yellow" bodies of precisely the same tint as the interrenal in Elasmobranchs. They vary in size and shape and are scattered through the kidney. They are finely lobulated and have processes. Some of the larger bodies are visible on the surface of the kidney; a still larger number come into view on slitting up the posterior cardinal sinus. The larger bodies are placed anteriorly, and indeed the most striking feature about their arrangement is their extreme anterior position as compared with those of Teleosts.

I have not been able to make out any very intimate relations between the suprarenals and the sympathetic in the Sturgeon.

5.—In the Teleostei the suprarenals are usually two in number, placed on either the dorsal or ventral surface of the kidney, usually near its posterior extremity. Sometimes they are embedded in the kidney substance, at other times they lie free on its surface. For details I must refer the reader to the original paper.

B.—Histology.

The following points in histology are either new or have not been sufficiently emphasised by previous observers:

1.—In Elasmobranchs *the interrenal body consists of definite alveoli, containing cells with large nuclei, and curious structures somewhat resembling the "demilunes"* of mucous glands.

The alveoli are seen in some parts of the gland to be arranged in a radiating manner round veins or venous sinuses. The general appearance is very like that of the cortex of a Mammalian suprarenal, and it is almost identical with the cortical cell-columns of Amphibians and Reptiles.

2.—*The segmentally-arranged bodies in the Elasmobranchs have no cortex and medulla (though so described by Balfour), no definite alveoli, and, for the most part, no definite cell-outlines.*

This curious indefiniteness marks off the paired suprarenals of the Cartilaginous Fishes from all the other structures we shall have to consider. The main part of the parenchyma appears to consist of an irregular or wavy fibrous stroma, with protoplasm and scattered nuclei, mostly oval. The nuclei are of different characters, sometimes shewing nuclear figures, at other times devoid of them; sometimes large and faintly stained, sometimes small and darkly stained. There are, however, in some places, *branched pigment cells* which appear to communicate together by their processes. The nuclei are of very varying size. *These segmental bodies, having such a different structure from the interrenal, are almost certainly different both morphologically and physiologically.*

The fibrils which Balfour described in these bodies were

probably many of them connective tissue, and not nerve-fibrils. I find that, apart from definite ganglia, nerve-fibrils are not more abundant in these organs than in glandular structures generally ("interstitial plexuses"). In fact, in my opinion, the *significance of the relations of the paired suprarenals to the sympathetic, has been much overstated; their relation to the vascular system is probably much more important.*

3.—The suprarenals in the Sturgeon, when treated with osmic acid, shewed rounded or elongated oval alveoli marked in bold outlines, and the cell-outlines were admirably preserved. The preponderating shape of the cells was round or oval, and in some parts the cells were seen to overlap, as the section was thick enough to contain several layers. In other parts the cells were more polyhedral or irregular in shape. The protoplasm was finely granular as a rule, occasionally more coarsely granular.

The above is obviously "cortical" structure. I have so far found no trace of medulla in the Ganoid organ. There are, however, large nervo-ganglia in connection with some of the bodies. There is no doubt that the above *structure shews these bodies to be the true suprarenals of Ganoids.*

4.—The suprarenals of *Teleostei* likewise consist entirely of cortical material. They are surrounded by a fairly thick fibrous capsule, which is thicker throughout the area in contact with the kidney. This capsule sends in trabeculae, forming eventually regular alveoli, strikingly suggestive of those of secreting glands. These are, as a rule, completely filled with cells, but in some species there is a space in the centre of each. This space is, however, partially occupied by scattered cells, nuclei, and shreds of protoplasm.

The suprarenal cells are of two kinds. The first are irregular branched cells with very large nuclei, containing a nuclear network and nucleoli. The second kind of cell is usually irregularly triangular with a small dark nucleus. These two kinds of cell are both usually present, but in very varying proportions; at present I can form no opinion as to their significance.

5.—In the *Dipnoi* nothing is known of the suprarenals. In *Pro-*

topterus annectens, Newton Parker describes certain masses of brown cells around the kidney, which, he says, remind one of the adrenal bodies of Amphibia. I have examined this point with some care both in *Protopterus* and *Lepidosiren*. I have carefully compared both these with the pigment patches in other parts, and find that they are quite comparable to these, so that, on the whole, I am inclined to the view that they have nothing to do with the adrenals. Besides, there is really very little resemblance in these pigment masses to the cell-columns and masses of the Amphibian suprarenal. But there *is* a very striking resemblance between the large-celled adenoid tissue which surrounds the kidney, and the suprarenals of a frog. In some parts of this tissue the masses of cells seem to be arranged in a columnar manner, and darkly-stained masses are seen here and there which remind one forcibly of the medullary substance in the suprarenals of Amphibians. But although I am convinced that somewhere in the neighbourhood of the kidney suprarenals will be discovered, my specimens were not sufficiently fresh to warrant me in deciding that they are constituted by the above tissue.

C.—Relations of the Suprarenals to the Head-Kidney in Teleosts and Ganoids.

1.—*All Teleosts and Ganoids, as far as is known at present (except Lophius, Dactylopterus, Fierasfer, Orthagoriscus mola, Mora mediterranea,* and the Macruridae*) have a "lymphatic head-kidney."*

2.—This head-kidney is a lymphoid organ with a probable blood-destroying function.

3.—The kidney of fishes consists of two quite distinct parts: (1) the secreting tubules and Malpighian bodies, and (2) an adenoid intertubular material.

4.—The head-kidney in adult Teleosts is not a "specialised" portion of the primitive kidney, but simply an accumulation at the

* Holt and Calderwood, "Survey of Fishing-grounds, etc.," Scientif. Trans. Roy. Dub. Soc. Vol. V (Ser. ii), IX, 1895.

anterior end of the organ of the lymphatic tissue which exists between the tubules throughout the kidney.

5.—*There is, so far as I can make out, no anatomical or physiological relationship of any kind between the suprarenals in Teleosts and the lymphatic head-kidney.*

PART II.

The Suprarenal Capsules in Amphibians and Reptiles.

1.—Historical.

The earliest account of the suprarenal bodies in Amphibians or Reptiles seems to be that of Swammerdamm (11) in 1738 who noted two yellow bodies on the kidneys of a frog and called them "corpora heterogenea." Morgagni described a viper in which he had found them. A little later Cuvier says, "Ceux des ophidiens et des sauriens sont dans le repli du peritoine, qui réunit les ovaires et les oviductes." In 1806 Meckel found in several snakes no trace of suprarenals. One can only conclude that his material was not fresh.

In 1818 Carus (2) dealing with the Batrachians only, described the fat bodies as suprarenals. In the next year Bojanus (1) mentioned elongated glandular bodies lying on the inner border of the kidney of the tortoise *(Emys orbicularis)*. Morgagni had previously described these, and these two observers agreed that the structures in question were suprarenal bodies.

Rathke (9) in 1825 says, "Das goldgelbe Gefüge, übrigens, welches an der untern Nierenfläche erwachsener Frösche und Kröten vorkommt, sich in der Mitte jener Fläche als ein mässig breiter Streifen hinzieht, und meiner Ansicht nach als die Nebennieren betrachtet werden muss, fehlt bei den ganz jungen Larven durchaus, entwickelt sich aber schon gegen die Mitte des ersten Sommers,

indem anfänglich einzelne solche Flecken zum Vorschein kommen, darauf sich weiter ausdehnen, und zuletzt unter einander verschmelzen."

In 1828 Carus (2B) announces distinctly that he considers suprarenals only to belong to Mammals and Birds (!). Retzius in 1830 (10) described rather minutely the suprarenals of snakes. He examined *Python bivittatus*, *Vipera berus*, *Coluber natrix*, and *Anguis eryx*. In all these, he says, the suprarenals were very distinct and were placed near the trunks of the Venae renales abducentes.

In 1836 appeared Nagel's paper (8), in which he reviews the work up to date, and makes some verifications and additions. He agrees with Bojanus that the suprarenal capsules in the Chelonia are two long bodies situated at the inner margin of the kidneys.

A few years later, in 1841, Gruby (6) thus described the "Reins succenturiés" of the frog:

"Les reins succenturiés sont placés sur la surface intestinale des reins; . . . . Leur couleur est jaune pâle; ils ont 11 millimètres de long et 1 millimètre de large . . . . ils forment des arcs; on en voit trois, dont l'antérieur est le plus large et le dernier le plus étroit; ces arcs couvrent les arcs du sinus veineux et quelques réseaux veineux de la surface des reins . . . ." He concludes:

"Les reins succenturiés jouent un plus grand rôle chez les Grenouilles que chez les Mammifères, chez lesquels ils constituent un organ fœtal seulement; chez les Grenouilles, au contraire, ils grandissent à mesure que l'individu croît; et ils sont, commes les reins eux-mêmes, mieux développés chez les adultes comme chez les individus jeunes. La position de ces organes sur la surface corticale des reins, la relation intime qui existe entre eux et les veines rénales, surtout la liaison entre les sinus veineux et leur tissu, leur structure intime, comme corps glanduleux sans conduit excréteur, leur couleur même, démontrent que ces organes ne sont autre chose que les reins succenturiés."

Five years afterwards, in 1846, appeared Ecker's work.(4) This observer seems to have been the first to recognise that the suprarenal bodies in the Chelonia lie on the abdominal surface of

the kidney and extend almost the whole length of the organ. Ecker considered that they corresponded, both as regards form and situation, with the similar organs in the frog. We shall see, however, later on, that the organs in the Chelonia are not very different in general arrangement from those of the other orders of Reptilia. Ecker gives a good account of the suprarenals in the Reptilia and Amphibia, including their microscopic structure. In the suprarenals of *Lacerta agilis*, this writer found that the presence of a membrana propria around the gland-vesicles was especially indistinct. He could only make out masses of a darkish substance. These masses consisted of fatty granules, which contained a nucleus, and possessed a size of 31 to 44 – 10,000ths of a line. In his examination of the *Testudo graeca* Ecker found microscopically that the suprarenals consisted of yellow granules which are grouped together in heaps. Each of these is enclosed in a membrana propria, and thus constitutes a gland-vesicle. Their contents are altogether identical with those of the Batrachians.

In the tailless Batrachia, according to Ecker, the yellow lobules already described consist of groups of vesicles. "Their form varies; sometimes it is round, sometimes oval, sometimes elongated or irregular. The vesicles are always closed. . . . . Fatty granules constitute the greater part of their contents; but besides these the fine granular substance is also present. Clear spots may also be seen glimmering from amidst the contents of the gland, and isolation shews these to be cells of 5 to 9 – 1000ths of a line in diameter, with finely-granular contents and a nucleus. The application of water renders this more visible. Part of these cells are devoid of the cell-membrance, but others of them exhibit it very distinctly. Besides these, free nuclei are found; these are sometimes vesicular and contain a nucleolus, sometimes they appear to be granulated. The nuclei which are included in cells are always of the latter kind." I am unable to say whether the above indicates that Ecker made out a distinction between what we now call the cortex and the medulla. This observer states that the same structure obtains in the tailed Batrachians, only the nuclei and cells are larger, while a part of the latter are completely enclosed in fat.

In 1852 Frey (5) gives a very good account of the subject, mostly after Ecker. It is clear from his account that the suprarenals in Reptilia were not well understood at that time; indeed he says—"Only isolated (and not unfrequently contradictory) observations have been made respecting them. Frey gives the following account of the general anatomy in Amphibia:

"Among the tailless Batrachia the suprarenal appears as a golden-yellow streak, which does not extend the whole length of the kidney, but ceases at a distance of one line from its upper and of two lines from its lower end. A lobular composition can be very distinctly discerned; and they do not extend along the kidney in a straight line, but usually digress into the arched form. They surround the trunks of the efferent renal veins at their exit from the substance of the kidney, so that they seem to be, as it were, perforated by this vessel.

"In the tailed Batrachia, on the other hand, we no longer find the suprarenal capsules in the shape of this connected streak, but broken up on all sides into from twenty to thirty separate and irregular lobules. These are seated, partly in the substance of the kidney at its inner border, partly between the kidney and the inferior cava; while they are also deposited on the coats of the latter vessel, and the gland-lobules have the same relation to the efferent renal veins as in the tailless Batrachians.

Leydig (7) in 1853 points out the intimate relationship between the sympathetic nervous system and one portion of the suprarenals of *Salamandra*. He examined also *Proteus* and *Lacerta agilis*. I will quote some of his conclusions:

"Der Rindensubstanz der Nebennieren von Saügethieren entsprechen die bisher bekannt gewesenen gelbkörnigen und streifigen Nebennieren der Fische und Amphibien. Wenn auch bei den Säugern kann der Inhalt der Blasen, aus denen die Rindensubstanz besteht, ausser den Kernen 'bald mehr, bald weniger, oft fast lauter Fettkörnchen' (Ecker) sein.

"Der Marksubstanz der Nebennieren von Saügern, die nach übereinstimmenden Beobachtungen von Nagel, Bergmann, Pappenheim, und Ecker einen überaus grossen Nervenreichthum und

Zellen besitzt, die den Ganglienkugeln sehr ähnlich sind, setze ich gleich die von mir bei Plagiostomen und Reptilien gefundenen eigenthümlichen Blasen mit Zellen, die Abschnitte der sympathischen Ganglien darstellen, und kontinuirlich in die bisher bekannt gewesenen Nebennieren sich fortsetzen."

Again: "Ausser der direkten Beziehung der Nebennieren zum Nervensystem ist aber auch unverkennbar, dass sie bei Fischen, Reptilien, und Saügethieren eine innige Relation zum Gefässsystem haben."

Stannius, in his text-book, gives a very good summary of previous work, but he makes no reference to Leydig's results. Probably the account was written before Leydig's work was published.

It was not, however, till 1871 that any really satisfactory account was given of the Histology of the suprarenals in Amphibians and Reptiles. The following is Eberth's account in Stricker* (3):

"In the adrenals of Batrachians, Saurians, Chelonians, and Birds, the cortex and medulla are not arrranged in layers as in Mammals, but the two substances are placed side by side, in rounded heaps, or in branched cords and columns.

In the Batrachia the most superficial portions of these organs are composed of solid roundish and elongated groups of polygonal cells, filled with fat molecules. These correspond to the proper cortical substance. The medullary portion, which is much more sparingly developed than in other animals, is here only represented by small isolated accumulations of polygonal cells, which are superimposed on the cortical portion. In its deeper parts the latter consists of branched and anastomosing columns of cells that decussate with similar columns of the medullary substance. Both the columns and the cell-masses are destitute of a membrana propria." It will be seen from my description below that this membrana propria is usually present both in Amphibians and Reptiles.

* *New Sydenham's Society's Translation*, 1872.

2.—List of Species Examined.

Amphibia.

Urodela (Caudata).

Salamandrina.

Salamandrinæ . . . . *Salamandra maculosa.*

Anura (Batrachia).

Oxydactylia.

Ranidæ . . . . . *Rana temporaria.*

Rana esculenta.

Bufonidæ . . . . . *Bufo vulgaris.*

Hylidæ . . . . . *Hyla arborea.*

Reptilia.

Ophidia.

Colubriformia.

Colubridæ . . . . . *Tropidonotus natrix.*

Coluber longissimus (Aesculapii).

Lacertilia.

Vermilinguia.

Chamæleonidæ . . . . *Chamæleon vulgaris.*

Brevilinguia.

Scincoideæ . . . . . *Anguis fragilis.*

Fissilinguia.

Lacertidæ . . . . . *Lacerta viridis.*

Lacerta muralis.

Agamidæ . . . . . *Uromastix Hardwickii.*

Chelonia.

Chersidæ . . . . . *Testudo Tabulata.*

Testudinæ . . . . . *Malacoclemnys terrapen.*

Emydæ . . . . . *Emys orbicularis.*

3.—Gross Anatomy in Amphibia.

There is not a great deal to be said on this head, but as the text-books dismiss the suprarenals with such scant notice, it may be well to state briefly what is their usual anatomy.

The suprarenals are golden-yellow streaks on the ventral surface of the kidney, of about 15 mm. in length in the frog to about 28 mm. in a good-sized toad. Their width varies in a similar manner from 1 to about 3 mm. But their dimensions vary very considerably according to the size and development of the particular individual.

There is not any appreciable difference between the arrangement in the different families of tailless Amphibians, so that the description will do equally well for the frogs and the toads.

In a good-sized specimen the suprarenals present on the ventral surface of the kidneys a very beautiful appearance, forming on each side a series of irregular arcs with their convexity outwards, and varying in width from place to place. Their colour is a bright golden-yellow of a somewhat fatty aspect, and their surface is marbled with veins running in all directions. Their average dimensions are given above; but it is noteworthy that in both frogs and toads, although the suprarenal reaches nearly up to the anterior end of the kidney, it always ceases at a point anterior to the posterior fifth of that organ.

The adrenal is not quite continuous, but is broken up on each side into a varying number of portions, separated by slight intervals. With a lens, or sometimes even with the naked eye, they seem to consist of a series of parallel lines, presenting a distinct transverse lobular appearance something like that of epididymis.

As far as I can make out, the blood-supply is the same as that of the kidney substance, *i.e.* it receives arterial blood from the dorsal aorta and venous blood from the Renal Portal vein. But there are no capsular arteries direct from the aorta; whatever arterial blood the bodies receive, they get indirectly from the arterioles distributed in the kidney. The tributaries of the Posterior Vena Cava, bringing impure blood from the kidney, run for some distance longitudinally along the anterior surface of the kidney and around this part of their course the suprarenal substance is collected. There are some three or four of these branches on each side. It would almost appear as if the suprarenal had had its exact location on the surface of the kidney determined by these

veins, for the discontinuity above mentioned corresponds to some extent with the occurrence of the venous tributaries.

In some cases the suprarenal capsule appears to be no more than a kind of glandular wall to the vein, and this explains the fact first noticed by Gruby, that when the blood-vessels are distended the suprarenals become less distinctly visible.

Among the tailed Amphibians I have only been able so far to examine a specimen of *Salamandra maculosa*. The only noticeable differences in the anatomy between it and the Batrachia are, that in the Salamander the suprarenal consists of a series of dots along the kidney instead of a continuous streak, and that these extend quite to the hinder end of the kidney instead of ceasing at about the posterior fifth as in the Batrachians.

4.—Gross Anatomy in Reptilia.

Whereas in the Amphibia the suprarenal is in close anatomical connection with the kidney, in the Reptilia it bears a close relation to some part of the reproductive apparatus. Thus in the Lacertilia (as has been pointed out by Ecker, Nagel, Frey, etc.) it lies upon the vena renalis revehens. In the male lizard the suprarenal capsules are placed between the vein and the vas deferens; in the female they are situated between that vessel and the ovary. In a male *Lacerta viridis* I have found the suprarenal on a level with the testis between the epididymis and the vein. In the Chamæleon and in *Anguis fragilis* the same arrangement obtains.

In the Ophidia the anatomical relationships are practically the same as in the Lacertilia, *i.e.* the suprarenal is situated between the postcaval vein or one of its tributaries and the reproductive gland.

In the Chelonia it has often been supposed that the suprarenals revert to the condition found in the Amphibia, *i.e.* that they lie on the ventral surface of the kidney. But on careful examination it will be seen that they bear almost precisely the same relationships to the reproductive system and the veins as in the other Reptilia. They do certainly lie in close connection with the

kidneys, but it will be seen that they have a still closer connection with the ovary or testis, and the proximity to the kidney is simply due to the fact that in this order the kidneys and reproductive organs are on about the same antero-posterior level.

I have not been able to obtain specimens of Crocodilia.

5.—Histology in Amphibia.

Bufo vulgaris.

When the kidney was cut into pieces and put into 1% osmic acid for twenty-four hours, then soaked in gum, and afterwards cut with the freezing microtome, the following results were obtained:

Sections were cut transverse to the long axis of the kidney. The suprarenal body was seen on the surface of the kidney as a mass of tissue surrounding the large vein which runs nearly the whole length of the body, and is a tributary of the posterior vena cava.

The cells appeared very granular, but the details were not well shewn, and I have only given this description to serve as a general type of the arrangement of the suprarenal tissue in the Frogs and Toads.

When the tissue was hardened, stained, and cut in paraffin, the appearances were almost exactly the same as in *Rana temporaria* (q.v.), except that the "medullary substance" is more scattered than in Rana, and in smaller patches (Pl. I., fig. 2).

Rana temporaria (Pl. i., fig. 1).

The suprarenal forms a distinct bulging on the ventral surface of the kidney, as shewn in transverse section. It appears to be enclosed in the capsule of the kidney, and there is no sheath or septum of any kind between the cell-columns and masses of the former and the tubules and Malpighian bodies of the latter. The line of demarcation between the two structures is, however, fairly definite, although there is no connective tissue boundary.

The gland is seen at once to consist of two distinct kinds of structure. The greater part is made up of columns of cells which are of varying size and shape and interlace in all directions (Pl. i., fig. 1, c). The cells are of different shapes, but mostly elongated and

tapering, and they contain a large round nucleus which stains very deeply with hæmatoxylin. In the nucleus can often be seen darker spots and patches (nucleoli?). This structure is the "cortical" which corresponds to the "interrenal" of Elasmobranchs, the suprarenals of Teleosts and the cortex of Mammalian suprarenal.

But in addition to the above-described structure we get masses of a different kind of cell. These appear to be quite irregularly distributed. The cells stain very deeply with hæmatoxylin and the nucleus is not so easily seen as in the above-described cell-columns, but is most often oval (Pl. i., fig. 1, m). This structure is almost certainly analogous to the paired suprarenals of Elasmobranchs and the medulla of Mammalian suprarenal, though it bears a much closer resemblance to the latter than to the former (Cf. Pl. i., fig. 1, and Pl. ii., fig. 6).

The cell-columns shew a very distinct basement membrane and the outlines of the cells are very clearly indicated.

The "medulla" is small in amount in proportion to the "cortex."

The organ has a very rich blood-supply. A network of capillaries runs between the alveoli, and large veins are abundant.

In *Hyla arborea* and *Rana esculenta* I have found practically the same structure, except that in Hyla there are no large masses of "medulla" and frequently solitary medullary cells.

It will be seen that in the above descriptions I have used the terms "cortex" and "medulla" as applied to the parts which are presumably analogous to the parts so-called in Mammals. But these are quite misnomers in Amphibians and Reptiles, for the "cortex" often occupies the central as well as other regions of the section, and the "medulla" is, as often as not, cortical in position.

Salamandra maculosa (Pl. i., fig. 3).

This is the only species of the tailed Amphibians I have been able to obtain; and as Leydig's account of the suprarenals in "Fische und Reptilien" was practically based upon an examination of this animal, I have studied the histology very carefully. After doing so I have failed entirely to verify the above observer's state-

ments concerning the relation of the suprarenals to the sympathetic ganglia. I have searched through whole series of sections, and I find no nerve-cells whatever in close relation to the suprarenals. This agrees with what I find in other Amphibians. In some Reptiles, indeed (v. *Tropidonotus natrix*, infra, and Pl. ii., fig. 6), I have found a close anatomical relationship between certain ganglion-cells and the medullary substance, but so far as my investigations go, no such thing exists in the Amphibians. In no case can I find any transition-forms or any cells intermediate in character between the granular medullary cells and characteristic ganglion-cells belonging to the sympathetic system. I find, in fact, that the suprarenal of *Salamandra maculosa* agrees in every respect as to its histological structure with that of the other Amphibians (v. Pl. i., fig. 3, cf. Pl. i., figs. 1 and 2).

6.—Histology in Reptilia.

Uromastix Hardwickii.

The suprarenals of this lizard were hardened in methylated spirit, double-stained in bulk with hæmatoxylin and eosin, embedded in paraffin, and sections were cut with the Rocking Microtome. The preparation was very successful, as the organ was removed while the tissues were still living, and the structure and cell-outlines are beautifully preserved. The sections shew the vas deferens on the one side, the vein on the other, and the suprarenal substance lying between them.

The organ is most obviously composed of two different sorts of cells which, like the similar structures in Amphibians, we may take to represent the cortex and medulla of Mammalian suprarenal.

The greater part of the body is made up of curved, irregular, branching, and interlacing columns of cells, about 50 μ thick and reaching a length of 120 μ (Pl. ii., fig. 5), consisting in most cases of a double row (as seen in section), but sometimes having three or even four tiers. The cells are 20 – 26 μ in length, and about 8 – 10 μ in width (see Pl. ii., fig. 5), and their protoplasm is very distinctly reticulated; near the centre of each is a large rounded or

oval nucleus (about 7×3 μ or about 5 μ in diameter), with a marked nuclear network and dark spots (nucleoli ?) (Pl. ii., fig. 5, p. and n.) This constitutes the "cortical" substance.

But in addition to these columns there are masses of cells of a different character, of various sizes and shapes, distributed through the gland (Pl. ii., fig. 5, m). There is a layer of these, for example, surrounding part of the circumference of the gland, and groups of five, six, or more cells, are found in different regions of the section. These cells are larger than the other sort, and very distinctly granular (see Pl. ii., fig. 5, m), the granules being of large size, rounded, and regularly distributed throughout each cell. They become very deeply stained with hæmatoxylin. This granulation obscures the cell-outlines to some extent. In these cells, also, the nuclear network and nucleoli can be easily seen. This structure is most probably analogous to the "medulla" of Mammalian suprarenal.

When the tissue has been hardened in Müller's fluid, the medullary cells are found to be stained brown, although the tissue be afterwards stained with hæmatoxylin and eosin. The hæmatoxylin in this case only stains the nucleus, leaving the cell-granules unstained. This fact is a further indication that these cells really correspond to the medulla of Mammalian suprarenal, for this may readily be picked out by the action of bichromate of potash. This reaction probably occurs with all Amphibians and Reptiles, though I have not tried it in every case.

In this preparation, in spite of the general structure being so well preserved, no distinct capillaries are shewn, but some of the interspaces between the columns of cells contain blood-corpuscles. It is, however, difficult to make out with certainty the vascular epithelium lining these spaces. There are to be seen in certain parts elongated nuclei immediately to the outer side of the basement membrane of the cell-columns, and these may possibly represent the nuclei of such epithelial cells.

In some parts of the structure the cell-columns are arranged in a radiating manner round the blood-containing spaces above described. This I found also in the interrenal of Elasmobranchs.

Lacerta muralis.

The medulla in this lizard is very compact, occupying a long strip and also a rounded mass quite separate from the cortex. In some specimens the medulla is altogether cortical in position, while the interior of the body is occupied entirely by cortex.

The cortical cell-columns are very like those in *Uromastix Hardwickii*, cell-outlines very distinct, but cells not quite so elongated. In many parts, after embedding in paraffin, the cells are vacuolated, indicating the presence of fat or of some fatty body (possibly a lipochrome) in the fresh cell.

In some sections the "medulla" appears in scattered masses between the cortical columns throughout the interior of the body, but so far as I have cut sections there is always more "medulla" externally than internally.

Lacerta viridis.

Here we have practically the same appearances as in *L. muralis.* The medullary substance appears to be irregularly distributed.

As in almost all cases except in *Uromastix Hardwickii*, the cell-outlines in the medulla are obscured or quite obliterated by the very deep staining with hæmatoxylin, so that all one sees in most cases is a patch of varying size in which the cells are only indicated by the nuclei and irregular masses of deeply-stained structure.

Anguis fragilis.

"Medulla" not very abundant, scattered, and not so deeply stained as in the last species. In some sections one sees a small amount of "medulla" at one end of the section only.

The columns or alveoli are very loosely bound together.

Coluber longissimus (Pl. ii., fig. 7).

The alveoli or cell-columns are much more definitely mapped out by fairly strong connective tissue boundaries than in the Lizards, and the cells of which they are composed appear to b

more closely packed; there is usually a very regular row of nuclei round the circumference of each alveolus.

Most of the cortical cell-columns contain, as seen in section, two rows of cells of an irregular columnar shape (see Pl. ii., fig. 7).

Tropidonotus natrix (Pl. ii., fig. 6).

The cortex has much the same appearance as in *Coluber longissimus.*

The medulla presents a very interesting appearance, as the whole is faintly stained, and so the medullary structure is clearer than in any of the previously examined specimens.

The characteristic feature of the medullary cells is that they contain abundant granules of large size which stain deeply with hæmatoxylin (see Pl. ii., fig. 6). These are in all probability the granules of the substance which these cells secrete, whatever that may be.

These medullary cells are sometimes quite isolated and surrounded by cortical substance. In other cases they are collected into groups of twos and threes, while in other parts they are gathered into columns or alveoli resembling in general form those of the cortex (Pl. ii., fig. 6).

The cells vary very much in shape, and their outlines are not always to be made out. As a rule they are branched and polygonal or stellate, but they may be irregularly columnar. *The structure is in fact almost identical with that of the medulla in some Mammals.*

In this medullary substance there are occasional nerve-ganglion cells beonging to the sympathetic system. They present the usual appearance of such cells (Pl. ii., fig. 6, n. c.) viz., a nucleated sheath, very finely-granular or almost homogeneous cell-protoplasm, large bladder-like nucleus, and a nucleolus. The cell-protoplasm has shrunk away from the nucleated sheath in some places, while it has remained attached at certain points, thus giving the cell an adventitious multipolar aspect.

Testudo tabulata.

The cortex is of the same character as in the Ophidia, except

that the cell-columns are separated by a slightly larger amount of connective tissue, and there are also larger septa dividing up the organ into several compartments in which "cortex" and "medulla" are irregularly distributed.

The medulla shews the usual darkly granular aspect, and, being deeply stained, the cell-outlines cannot be distinctly made out. In some slides a large ganglion is seen between the external connective-tissue boundary of the organ and another strong septum which separates it from a mass of medullary substance.

There is a large amount of connective tissue running in the form of strong bands throughout the organ.

Malacoclemnys terrapen.

In this tortoise the structure is almost identical with that of the foregoing. One sees larger or smaller groups of nerve-cells (or sometimes even single ones) embedded in, or in immediate relation to, some portion of the medullary substance.

7.—General Conclusions.

It will have been noticed from the above account that *I have not been able to find any relation between the medullary substance and the sympathetic ganglia in the Amphibia.*

In the Reptilia, however, nerve-cells of large size are to be frequently found both around and in the substance of the gland. But it is noteworthy that *when nerve-cells are found in the substance of the suprarenal they are always either surrounded by, or near to, a portion of medulla.* They are never isolated in the cortex. So that certainly it does appear that the medullary substance bears a closer relation to the sympathetic nervous system than does the cortex.

Nowhere can I find any indication of cells intermediate in character between the granular medullary cells and nerve-ganglion cells. The nerve-cells when found are ordinary sympathetic nerve-cells, and are carried into the substance of the body by strands of connective tissue and nerve-fibres.

I have not entered upon any investigations into the development of the suprarenal capsules. There are two theories concerning the origin of the cortical substance which hold the field: one that of Weldon, according to which this portion of the gland develops from the Wolffian body; the other that of Mihálkovics, who states that it has been derived from the germinal epithelium. The latter seems to me, from a consideration of its minute structure, to be the more probable.

With regard to the medulla, most writers since Balfour are content to say that "it is developed in connection with the sympathetic system." Having myself not worked at the development I do not wish to be dogmatic, but I am at present not willing to admit that the medulla is essentially of nervous origin.* The facts about the connection between the sympathetic nervous system and the suprarenal bodies seem to me to be as follows:

In Elasmobranchs we get the "paired suprarenals" which correspond to the medulla in mammals, and the "interrenal" which corresponds to the cortex in mammals. *These are two distinct kinds of secretory structure, or in other words two distinct secreting glands, and the suprarenal of higher vertebrates is therefore to be regarded as a double secreting organ having probably two distinct functions.* In Elasmobranchs the paired bodies have for some reason or other, become very intimately connected with the ganglia of the sympathetic, and this connection, although I cannot verify its existence in the Amphibia, obtains as high in the scale as the Reptilia. This intimate relationship has practically disappeared in the Mammalia, so that here we get simply a double secreting gland with an abundant sympathetic nerve supply.*

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* It is on the whole more likely that the ganglion-cells of the sympathetic have developed from the cells of the medulla of the suprarenal, than that the latter have developed from the former.

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See also textbooks of Cuvier, Meckel, Wiedersheim, Gegenbauer, and Stannius.

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* *i.e.* the same sort of sympathetic nerve-supply as the other abdominal viscera. I have made preparations of a guinea-pig's suprarenal by Golgi's (Ramon y Cajal's) method, and I find that in the medulla, and also to some extent in the cortex there are finely-ramifying nerve-cells, just such as Cajal describes as interstitial cells of the pancreas.

† For references on Fishes, see paper in Trans. Zool. Soc.

9.—EXPLANATION OF PLATES I & II.

Reference Letters common to all the Figures.

c. cortex, *m.* medulla, *i.* interspaces between the cell-columns, *n.* nuclei, *p.* protoplasm of cortical cells, *g.p.* granular protoplasm of medullary cells, *bld. c.* blood-corpuscles, *c.t.* connective-tissue, *n.c.* nerve-cells, *k.t.* kidney tubules, *Mal.* Malpighian bodies, *k.* kidney.

PLATE I.

Fig. 1.—Section shewing relation of suprarenal to kidney substance in *Rana temporaria*. Low power.

Fig. 2.—Small portion of suprarenal of *Bufo vulgaris*. Leitz, panta-chromat. 3·0 mm. [Slightly diagrammatic.]

Fig. 3.—Section through a portion of kidney of *Salamandra maculosa*, shewing suprarenal.

Fig. 4.—A portion of suprarenal of *Lacerta muralis*. Low power.

PLATE II.

Fig. 5.—Small portion of suprarenal of *Uromastix Hardwickii*, Leitz, Panta-chromat. 3·0 mm. Drawn with Abbe's Camera lucida. The preparation was a very successful one, and my drawing does not adequately represent the delicacy and clearness with which the details are seen.

Fig. 6.— Small portion of medullary substance of *Tropidonotus natrix*, with nerve-cells. [Highly magnified.]

Fig. 7.—Portion of suprarenal of *Coluber longissimus*.

Fig. 1.

Fig. 2.

Fig. 3.

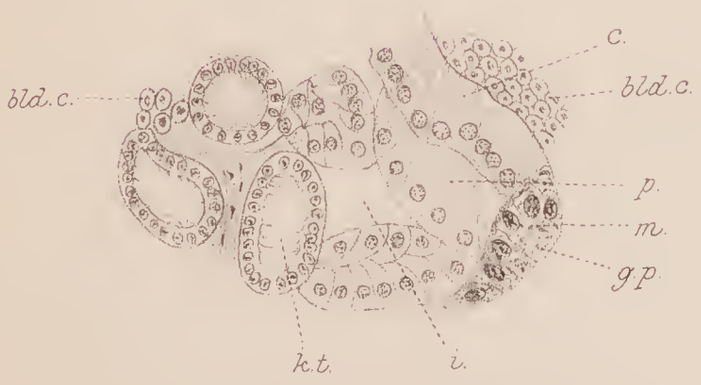


Fig. 4.

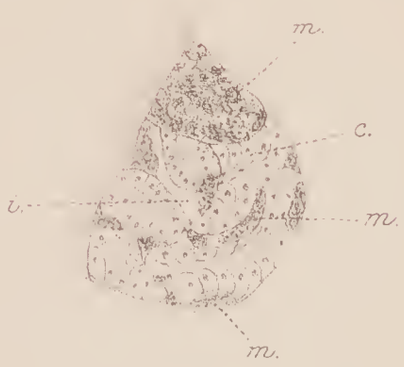


Fig. 5.

Fig. 6.

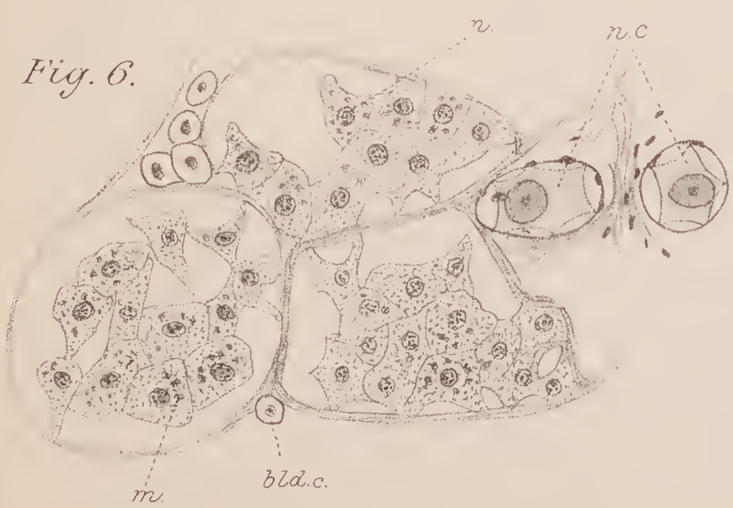
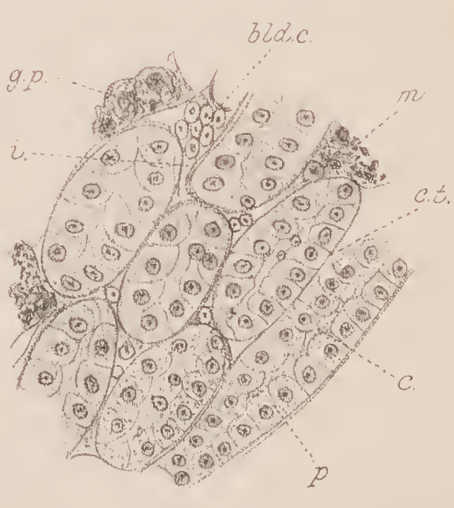


Fig. 7.



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II.—*On the Anatomy of the Symelian Fœtus.**

By T. Manners-Smith, M.A. Cantab., M.R.C.S.

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[This paper, of which the following is an abstract, was published in the *Journal of Anatomy*, of January, 1896. The work was greatly assisted by a Grant from the Endowment of Research Fund, and I take this opportunity of expressing my thanks to the Council for the assistance they have given me.]

"The occurrence of Symelian monsters is of sufficient rarity to make each case worthy of careful anatomical examination, with a view to a more complete classification, and, if possible, to throw some light upon the causation of this form of monstrosity.

Neglecting the fanciful descriptions of the teratologists of the sixteenth and seventeenth centuries, such as Lycetus, Lycosthenes, Palfin, Rueffus, the first systematic description of these monsters, from a strictly objective and purely anatomical point of view, occurs in the writings of Haller, published between 1735 and 1753. From this period to the time of Saint-Hilaire, who was the first to elevate the study of monstrosities to the level of a science, various observations were made from time to time by Bœrhaave, 1757; Sachsse, 1803; Otto, 1811; Dieckerhoff, 1819; Meckel, 1826; Cruveilhier, 1827; and Behn, the last observer, in his work *De-monopodibus*, was the first to point out that these monsters possessed only one umbilical artery. The principal contributions of the last

half century are those of Vrolik, Solger, Gebhard, Odisio, and Benington, to which authors frequent reference is made in the text.

In the following account I have described the bones, muscles, and nerves of the two monsters coming under my notice, and I have compared their anatomy with that of many of the specimens of the above-mentioned authors.

Nomenclature.

Before the time of Saint-Hilaire, Symelian monsters were described somewhat loosely under the names Monopodia or Monopedia, names which, as Saint-Hilaire pointed out, it would be better to reserve for those monstrosities possessing a single inferior extremity and foot. Other observers have adopted as a class-name for this family of monstrosities, the term Sireniforma, or Sirenlike, from the fancied resemblance to the sirens of mythology. This name, as Saint-Hilaire has also pointed out, should be reserved for a certain variety of Symelian monsters, only, namely, that without feet. Cruveilhier preferred the less correct but more picturesque and more easily intelligible descriptions, either Monopodia or Sirens.

Saint-Hilaire's classification was as follows:—(1) The two inferior extremities united, almost perfect, terminated by a double foot, the sole of which is turned in front: *Symèle* or Symeles, the Sympus dipus of other authors. (2) The two inferior extremities united, very incomplete, terminated by a single foot, almost always very imperfect, the sole of which is turned in front: *Uromèle* or Uromeles, the Sympus monopus of other authors. (3) The two inferior extremities united, extremely incomplete, terminated in a stump, or in a point without a distinct foot. *Sirénomèle* or Sirenomeles, the Sympus apus of other authors.

The specimens which came into my possession, through the kindness of Dr. Windle, were two in number, one belonging to the class Symeles, the other to the class Sirenomeles; a third specimen, which at first sight appeared to belong to the class Uromeles, turned out, on dissection, to belong to the family Monopodia."

Summary of the chief interesting Anatomical Peculiarities of the Specimens examined and collected.

1. The frequent abnormality in the number of the vertebræ.
2. Articulation of last lumbar vertebra with ilium.
3. The scoliosis frequently found in the lumbar or dorsal regions.
4. The unsymmetrical condition of the ribs.
5. The ilia appear to be, as a rule, separate in Symeles, but fused in Sirenomeles.
6. The rudimentary condition of the ischia and pubes.
7. Patellæ separate, as a rule, in Symeles: fused in Sirenomeles.
8. Fusion of the femora by their outer, not by their inner surfaces.
9. The diminution of the leg and foot elements from the fibular to the tibial side.
10. The absence of the gluteal muscles in the specimens belonging to the class Sirenomeles.
11. The partial intra-pelvic origin of one or other of the gluteal muscles.
12. The frequent absence or diminution of the small external rotator muscles.
13. The almost constant absence of one or other of the hamstring muscles.
14. The absence or rudimentary condition of the calf muscles.
15. The fusion of the flexor longus digitorum with the flexor longus hallucis.
16. The fact that the nervus furcalis is in some cases the fifth lumbar nerve instead of the fourth on one or both sides, together with the fact that in one of the same cases there were thirteen ribs on the left side and six lumbar vertebræ.
17. The unsymmetrical condition of the sacral plexuses.
18. The fusion of the elements of the great sciatic nerves.

13. The rudimentary condition of the sacral plexus in the specimens belonging to the class Sirenomeles.
20. The fusion, in almost all cases, of like parts.

Theory as to Causation.

Saint-Hilaire explained the formation of these monsters by what he termed the law of affinity of like for like (*Loi de l'affinité de soi pour soi*); that is to say, that the union was what he described as "a natural" process, and quite as natural a process as the union of other parts, which at first paired and were lateral, afterwards became united. That the reason why the extremities do not as a rule unite, was because they never have the opportunity of coming into contact. In favour of this view, he quotes the fact that the upper extremities are never found united, in consequence of the thoracic cavity intervening; that, normally the lower extremities are separated in a somewhat similar manner, though not to the same extent, by the pelvic elements; but that these, failing in some cases, the lower extremities are able to come in contact, and, as a result of this, fusion takes place. He states that we should rather wonder that union does not more frequently occur, than that it occurs only occasionally. Cruveilhier, though expressing his admiration for the above view, points out that the fœtal lower extremities are frequently in contact without union occurring. The same observer criticises adversely the view of Meckel, namely, that this class of monstrosity was due to an original malformation of the germ. Cruveilhier himself adopts the view that both the fusion and the rotation are due to pressure, both lateral and antero-posterior. Tiedemann and Serres considered the condition due to deficient arterial supply, the latter attributing it as due especially to absence of one of the umbilical arteries. Vrolik, after condemning the idea that this condition is due to absence of one of the umbilical arteries, and pointing out that one artery only is sometimes observed, both in the completely well-formed fœtus, as well as in double monsters, states that sympodia is due to some original malformation of the pelvis and its viscera, of which the cause remains unknown. He does

not even admit that the condition is due to a fusion of the extremities, and states that the regularity of transition of one form into another, *i.e.*, from simple abnormality of position, to fusion with more or less absence of structure, makes it impossible to ascribe the condition to accidental external causes. Solger explains the single umbilical artery as a continuation posteriorly of that process of fusion which forms the single dorsal aorta. He also explains the fusion of the limbs, by an approximation of the side plates from which the limbs are developed, and as a result of that approximation, fusion takes place. In this way he explains the blind condition of the rectum found generally in these monsters.

Gebhard believes that the fusion is due to compression by the amnion.

Camille-Darest believes that, in consequence of the non-development of the caudal end of the embryo, the limb buds, instead of descending upon the two sides of the body, are reversed and placed beneath the extremity of the embryo; coming into contact by their external border, they unite and form a single member.

In the absence of any direct knowledge as to the process of fusion, it seems to me that the theory of Saint-Hilaire, interpreted in the light of modern biological research, is the one which is the most satisfactory, viz., that there is an inherent tendency for the side plates or limb buds to unite, an affinity of like part for like part, understanding by affinity nothing more than a greater tendency for similar than dissimilar parts to fuse. That this tendency is latent, and is comparable to, and is possibly the descendant of, that fusion, which (adopting the most recent view as to the origin of paired and unpaired limbs) takes place in the posterior portion of the fin elements of certain fishes. Thus, it has been shown by Dohrn and Balfour that each somite gives rise to a fin element, each of which consists of two dorsal and two ventral bundles of muscle, two rods of cartilage and a corresponding spinal nerve. Both pectoral and pelvic fins are made up of a considerable number of these fin elements. These outgrowths are present along the entire length of the lateral epiblastic folds, and, while these abort

between the pectoral and pelvic fins, they converge and form the ventral unpaired fin in the region behind the anus, so that the ventral unpaired fin may have been originally paired, when the post-anal gut of the embryo and the cœlome extended throughout the whole caudal region. Without entering into the vexed question of the relationship of the fin of the fish to the limb of the higher vertebrates, and the homologies of these parts, I mention the above simply in support of the tendency to fusion-theory of Saint-Hilaire, that is, of parts which, at first, paired and lateral, afterwards become median and united, and in support of the extension of that theory to limb elements. Whether this tendency in the case of Symelians is called into activity by pressure or by failure of the limbs to rotate properly, or whether it has its origin in the tilting of one limb towards the other, in consequence of an unsymmetrically developed or articulated pelvis, there is no evidence, but from the unsymmetrical condition of the sides of the whole body, that is, of ribs, vertebræ, and pelvis, in many of the cases in which a careful description has been given, I should be inclined to favour the view that the last-named condition is the exciting cause. From the fact that only similar elements are united, and that all transitions are met with from instances where there is simple union of the feet, without absence of any of the limb elements, to those in which the leg is represented only by a stump-like extremity, together with the fact that the different species fall into definite classes, agreeing so exactly in their structure, it would seem that the pressure-theory alone is insufficient to account for the condition, unless there is some such affinity for like parts as Saint-Hilaire described. But, in whatever way the exciting cause has been set up, the fusion itself is possibly the result of a latent tendency, that tendency having been transmitted to the limb-bud from its homologous representative in certain piscine vertebrates.

RECORDS

OF

METEOROLOGICAL OBSERVATIONS

TAKEN AT THE OBSERVATORY OF THE

BIRMINGHAM AND MIDLAND INSTITUTE.

BY

MR. ALFRED CRESSWELL,

CURATOR OF THE OBSERVATORY.

[The accompanying Records and Charts have been drawn up by Mr. Cresswell at the request of the Society, and are published by permission of the Council of the Midland Institute.]

Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, The Monument, Waterworks Road, Edgbaston, Birmingham.

The Observatory is situated in North Latitude 52° 28′ 24″, and West Longitude 1° 55′ 40″, and is at an average elevation of 500 feet above the mean sea level.

Barometer.

The cistern of the standard barometer is 541 feet above the mean sea level, and the barometer is read twice daily, at 9 a.m. and at 9 p.m.

Temperature.

The temperatures given are the highest, lowest, and the 9 a.m. readings, from maximum and minimum thermometers, placed four feet above the ground in the shade. The solar radiation is the maximum temperature given by a blackened bulb thermometer in vacuo, exposed to the direct rays of the sun.

Rain.

The amount is given from a gauge placed one foot above the ground, and 525 feet above the mean sea level.

Sunshine.

The amount of sunshine has been obtained by a Jordan's sunshine recorder, placed on the top of The Monument, about 100 feet above the ground.

Horizontal Motion of the Air.

A continuous record has been obtained by means of Robinson's hemispherical cups, in connection with Osler's anemometer, which is situated on the top of The Monument, about 100 feet above the ground; the velocity being obtained on the assumption that the cups move with one-third the velocity of the air.

Extreme Wind Pressure.

The pressure plate of Osler's anemometer, from which this record has been obtained, presents a surface of two superficial feet to the wind. The direction at the time of greatest pressure, given to the nearest sixteenth point of the compass, has also been obtained from this instrument.

For all the self-recording instruments the day begins and ends at midnight. The maximum and minimum thermometers and the rain gauge have been read twice daily, at 9 a.m. and 9 p.m. The temperatures and rainfall thus recorded may be taken generally as occurring on the day for which they are entered.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hai

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Sola Radi tion Max
Jan. 1	29·393	29·965	B.	C.B.	27·0	34·4	26·0	63
2	29·289	29·859	C.	C.B.	36·3	39·9	28·2	69
3	28·959	29·523	C.	C.	30·8	35·8	29·6	57
4	29·431	30·004	C.	C.	31·5	35·5	29·0	58
5	29·490	30·064	C.B.	C.	29·9	33·6	27·2	42
6	29·222	29·791	C.	C. to S.	28·6	32·0	27·0	41
7	29·146	29·713	O.	C.	27·3	31·9	24·0	43
8	29·321	29·890	C.	C.	30 2	35·1	26·8	61
9	29·312	29·883	C.B.	C.	26·8	33 0	26·4	51
10	29·355	29·927	F.	**F.**	22·3	31·3	21·0	29
11	29·272	29·842	F.	F. to C.	16·5	25·5	15·3	42
12	28·979	29·543	C.	O. to S.	25·0	29·0	13·9	36
13	28·344	28·895	C.	C.	30·0	37·0	25·6	59
14	28·346	28·897	C.	C.D.	35·0	37·0	32 8	41
15	28·484	29·038	O.	R.	36·0	36·9	33·8	39
16	28·413	28·966	O.	R.	38·0	42·0	36·0	56
17	28·451	29·004	C.	C. & R.	36·3	40·5	34·8	44
18	29·060	29·626	C.B.	C.B.	32·6	41·6	31·0	**70**
19	29·132	29·699	R.	R.	39·9	**42·8**	35·0	47
20	28·898	29·460	R.	R.	37·0	40·0	33·5	41
21	29·117	29·684	O.	C.	33·0	37·0	30 0	56
22	29·248	29·817	S.	C.	31·0	39·1	27·7	63
23	29·001	29·566	C.	C.B.	39·6	41·1	29·0	66
24	28·723	29·282	C.	C.R.	36·4	41·1	27·4	66
25	28·973	29·537	C.B.	C.to s.to C.B.	32·0	36·6	23·1	68
26	29·154	29·722	C.B.	C.	26·0	32·0	22·6	54
27	29·162	29·729	B.	C.B.s.	22·0	29·5	19·8	68
28	29·450	30·023	B.	B.C.	20·6	29·0	20·0	61
29	29·593	30·169	S.	C.	24·0	28·6	21·1	44
30	**29·901**	30·484	s.	C.B.	23·0	29·9	20·4	64
31	29·773	30·312	C.		24·4	33·0	23·0	68
Extreme	**29·901**				30·0	**42·8**	13·9	**70**
Mean, or Sum.	28·344							

NOTE.—Heavy type indicates maximum or in large quantitie

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Jan. 1	...	3	20	466	19·4	2·5	5·15	N.N.W.
2	0 045	3	20	379	15·8	2·0	7·35	N.W.
3	*0·115*	...	30	347	14·5	1·5	*10·30*	N.N.W.
4	...	...	...	415	17·3	2·0	*10·45*	N.N.W.
5	...	...	...	358	14·9	2·0	7·10	N.N.W.
6	*0·150*	...	...	132	5·5	...	...	...
7	...	...	...	292	12·2	1·0	4·30	N.N.W.
8	*0 010*	...	...	276	11·5	...	...	...
9	...	...	...	176	7·3	...	...	...
10	...	...	...	43	1·8	...	...	...
11	...	...	20	77	3·2	...	...	...
12	*0·400*	...	...	389	16·2	6·0	*11·0*	E.S.E.
13	*0·400*	...	10	431	18·0	5·6	12·40	E.S.E.
14	0·170	...	...	286	11·9	2·0	2·30	S.E.
15	0·405	...	...	257	10·7	1·0	11·20	S.E.
16	0·105	...	10	260	10·8	...	...	...
17	0·200	...	...	310	12·9	2·0	*7·20*	W.N.W.
18	...	3	40	239	10·0	...	...	...
19	0·300	...	...	266	11·1	1·0	*9·40*	E.S.E.
20	**0·970**	...	...	373	15·5	2·0	*9·35*	N.E.
21	0·200	...	...	497	20·7	4·0	8·35	N.E.
22	*0·040*	...	10	338	14·1	2·5	9·50	W.
23	0·035	**3**	**45**	**561**	**23·4**	**9·0**	11·30	N.N.W.
24	0·165	...	40	506	21·1	8·0	*5·10*	N.W.
25	*0·020*	...	25	507	21·1	4·8	*1·25*	N.N.W.
26	...	...	...	263	11·0	1·0	3·20	N.N.W.
27	*0·030*	1	40	295	12·3	1·5	*10·30*	N.W.
28	...	3	30	455	19·0	2·5	2 50	N.N.W.
29	*0·125*	...	...	256	10·6	0·5	11·30	S.
30	*0·010*	3	0	360	15·0	2·0	*1·55*	E.N.E.
31	*0·025*	...	40	394	16·4	3·3	*3·35*	N.N.E.
Extreme Mean, or Sum.	3·920 Ital. = Snow melted.	25	20	10204	13·7	**9·0**	11·30 Ital. = P.M.	N.N.W.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Feb. 1	29·484	30·058	S.	C.S.	27·5	32·0	25·5	38·0
2	29·364	29·936	O.	C.	32·1	34·0	29·7	53·3
3	29·467	30·041	O.	O.	28·9	32·3	24·0	57·1
4	29·626	30·203	O.	B.C.	31·7	34·0	25·9	72·0
5	29·567	30·143	C.	C.	20·5	28·5	19·2	44·8
6	29·249	29·818	F.	B.C.	9·0	23·2	8·0	77·2
7	29·256	29·825	B.	B.C.	15·0	24·3	13·5	69·0
8	29·367	29·939	B.HZ.	C.	11·6	27·1	8·2	46·9
9	29·523	30·098	F.	F. to B.	13·6	31·2	13·0	65·0
10	29·256	29·826	O.	O.	18·4	27·0	15·7	57·3
11	29·108	29·675	C.	B.HZ.	24·8	29·9	22·6	62·3
12	29·322	29·893	B.HZ.	B.C.	20·0	32·9	18·0	68·4
13	29·561	30·137	B.	B.	23·0	36·2	18·4	78·0
14	29·686	30·264	B.	B.C.	20·1	26·7	18·0	67·9
15	29·715	30·294	O.	O.	24·8	29·5	19·6	40·0
16	29·879	30·461	B.	B.	25·3	33·3	24·4	71·0
17	**29·886**	30·468	O.	O.	27·4	32·0	23·2	43·5
18	29·778	30·358	O.	O.	28·2	34·6	25·0	45·2
19	29·715	30·294	O.	O.	32·6	36·1	30·8	51·0
20	29·792	30·372	C.	C.B.	31·1	38·0	27·1	66·9
21	29·779	30·359	O.	C.	31·3	38·1	27·2	53·4
22	29·776	30·356	C.	O.	30·8	37·0	26·6	50·7
23	29·732	30·311	O.	C.	35·9	41·0	33·2	66·3
24	29·256	29·826	C.	R. to C.	36·3	40·8	33·2	80·0
25	29·324	29·895	O.	C.	32·6	36·6	32·0	52·2
26	29·326	29·897	B.C.	B. to R.	31·3	39·6	27·8	75·5
27	29·229	29·798	B.	B. to C.	32·2	37·8	29·1	75·1
28	29·421	29·994	C.	C.B.	33·2	**43·6**	27·8	**89·8**
Extreme Mean, or Sum.	**29·886** 29·108				26·0	**43·6**	8·0	**89·8**

NOTE.—Heavy type indicates maximum or in large quantities;

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Feb. 1	*0·170*	...	...	308	12·8	1·0	*4·55*	E.
2	...	...	...	295	12·3	1·0	*10·5*	E.S.E.
3	...	...	...	402	16·7	3·4	*3·50*	E.
4	...	3	25	370	15·4	2·4	*3·10*	E.
5	...	...	...	257	10·7	1·5	*7·25*	N.E.
6	...	3	15	160	6·6	...	...	...
7	...	5	45	224	9·3	...	...	...
8	...	...	30	137	5·6	...	...	...
9	...	2	30	141	5·9	...	...	...
10	...	...	...	388	16·2	2·0	*4·30*	E.S.E.
11	...	3	10	321	13·4	1·0	5·30	E.
12	...	5	0	275	11·5	0·8	*12·25*	N.N.W.
13	...	**7**	**0**	166	6·9	...	...	...
14	...	5	0	326	13·6	2·0	*3·20*	S.E.
15	...	...	...	**478**	**19·9**	3·0	*10·30*	E.N.E.
16	...	6	30	455	19·0	**4·0**	11·20	E.N.E.
17	...	...	...	152	6·3	...	...	...
18	...	...	...	135	5·6	...	...	...
19	*0·010*	...	...	187	7·8	...	...	...
20	...	2	20	169	7·0	...	...	...
21	...	...	...	184	7·7	0·6	6·25	N.N.W.
22	...	...	...	205	8·5	0·6	*6·5*	N.N.W.
23	...	...	45	302	12·6	1·8	*12·55*	N.W.
24	*0·115*	...	...	302	12·6	1·8	*7·50*	N.E.
25	*0 010*	...	10	356	14·8	2·0	10·50	N.E.
26	*0·015*	4	40	290	12·1	1·2	*7·5*	N.W.
27	...	6	10	390	16·2	2·0	9·30	N.N.W.
28	...	2	0	278	11·6	1·3	*1·30*	W.
Extreme Mean, or Sum.	0·320 Ital. = Snow melted.	58	10	7653	11·4	**4·0**	11·20 Ital. = P.M.	E.N.E.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Mar. 1	29·134	29·701	B.	C.B.	40·6	45·3	37·0	92·2
2	29·202	29·771	C.	C.B. to s.	31·3	38·4	29·2	82·0
3	29·002	29·567	Hz.	B.Hz. to s.	29·0	35·1	24·2	77·2
4	29·231	29·800	B.	B.C.toC.&s.	28·2	37·0	24·0	67·0
5	29·350	29·921	Hz.	C.B.	31·0	38·9	29·0	72·9
6	29·190	29·758	C.	C.	35·1	42·2	32·4	74·2
7	29·186	29·753	R.	R. to C.B.	36·6	44·6	35·2	75·7
8	29·065	29·631	O.	O. to R.	33·1	40·2	31·2	53·0
9	28·987	29·551	O.	R.	37·5	40·0	36·5	47·3
10	28·746	29·305	C.	C.B.R.	40·0	46·3	36·5	94·0
11	28·957	29·521	B.	B. to B.C.	37·1	48·8	32·0	**103·0**
12	29·109	29·676	F.	C.	33·8	44·5	32·1	56·0
13	29·424	29·997	M.	C.	32·8	45·0	31·1	62·9
14	29·684	30·262	C.B.	B.C.	40·5	52·9	33·8	100·5
15	29·750	30·329	B.	B. to C.	45·0	50·7	38·3	95·1
16	**29·762**	30·342	C.	C.B.	44·0	53·3	40·0	76·6
17	29·711	30·290	B.Hz.	B.C.	40·3	57·4	36·1	95·6
18	29·626	30·203	F.	C.B.	33·3	56·8	30·4	92·2
19	29·443	30·016	O.	O. to R.	45·3	50·4	38·9	72·0
20	29·271	29·841	D.	D.	45·4	49·0	43·0	83·5
21	29·357	29·929	O.	C.B.	49·3	**58·1**	42·0	100·2
22	29·391	29·963	O.	C. to B.C.	44·0	53·3	43·0	84·4
23	29·285	29·855	C.B.	C.B.toC.toR.	48·0	52·0	39·0	93·9
24	28·610	29·167	R.	C.R. to B.	49·0	53·1	37·5	86·2
25	28·666	29·224	B.C.	B.C.	40·3	50·0	34·2	91·3
26	28·587	29·143	C.B.	C.B.R.	39·9	46·8	37·1	95·0
27	28·533	29·088	R.	C.R.	37·0	48·7	36·4	56·9
28	28·140	28·687	C.	R.	39·8	48·0	37·0	58·0
29	28·438	28·991	O.	C. to C.B.	37·0	42·8	33·8	88·9
30	28·708	29·267	O.	C.	38·0	44·1	36·0	84·7
31	28·949	29·512	C.	C.B.	38·6	45·9	36·0	95·0
Extreme Mean, or Sum.	**29·762** 28·140				38·7	**58·1**	24·0	**103·**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Mar. 1	...	3	55	455	19·0	3·0	3·10	W.
2	...	3	45	364	15·2	2·0	10·55	N.N.W.
3	*0·010*	1	55	229	9·5	1·0	*4·30*	N.N.W.
4	...	1	10	411	17·1	2·3	*12·20*	N.N.W.
5	...	3	10	221	9·2	...	...	...
6	...	...	45	366	15·2	2·0	11·35	S.S.W.
7	**0·235**	1	5	240	10·0	1·0	12·30	S.
8	0·190	...	...	390	16·2	2·0	*4·10*	S.S.E.
9	0·190	...	...	219	9·1	2·0	*3·35*	S.E.
10	0·115	1	0	359	15·0	5·5	*1·5*	S.S.W.
11	...	**7**	**40**	227	9·5	0·6	11·0	S.S.W.
12	...	...	...	153	6·4	...	...	...
13	...	...	15	189	7·9	...	...	...
14	0·020	3	25	265	11·0	1·0	*2·5*	W.S.W.
15	...	6	0	284	11·7	1·4	*12·5*	W.S.W.
16	...	...	50	150	6·2	...	...	...
17	...	7	0	180	7·5	...	...	...
18	...	5	20	173	7·2	...	...	...
19	0·070	...	5	440	18·3	2·6	*2·50*	W.
20	0·110	...	25	313	13·0	2·0	10·35	N.W.
21	0·030	3	15	330	13·7	2·0	*2·35*	N.W.
22	...	3	30	196	8·2	...	...	...
23	0·050	1	15	458	19·1	5·5	*8·10*	S.S.W.
24	0·200	2	50	**624**	**26·0**	**37·0**	*1·35*	W.S.W.
25	0·025	6	35	371	15·5	4·6	*2·25*	S.W.
26	0·060	4	35	374	15·6	3·5	*12·55*	N.W.
27	0·185	...	...	294	12·2	1·0	8·35	S.S.E.
28	0·205	...	...	586	24·4	9·0	*5·5*	W.
29	0·150	1	20	537	22·4	4·0	*6·25*	W.N.W.
30	0·065	...	35	305	12·7	1·0	2·25	W.
31	...	3	35	245	10·2	1·2	*3·25*	W.N.W.
Extreme Mean, or Sum.	1·910 Ital. = Snow melted.	75	15	9948	13·4	**37·0**	*1·35* Ital. = P.M.	W.S.W.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radia-tion. Max.
April 1	29·088	29·654	C.B.	C.B.	39·6	46·6	32·4	95·
2	29·391	29·963	O.	O.	37·4	40·7	35·0	47·
3	29·390	29·962	C.B.	C.B.	39·2	48·0	33·4	88·
4	29·549	30·124	O.	O.	34·6	41·5	32·2	55·
5	29·641	30·218	B.HZ.	C.B.	34·4	49·0	28·4	94·
6	28·900	29·463	C.	D.C.	43·8	49·0	35·8	68·
7	28·822	29·383	S.	S. to C.B.	33·7	46·4	33·0	94·
8	29·185	29·753	O.	C.	40·2	54·0	32·6	96·
9	29·282	29·852	C.B.	B.C.	49·1	60·2	46·0	110·
10	29·364	29·936	C.	B.C.	49·9	59·0	46·0	116·
11	29·708	30·287	B.C.	B.C.	46·4	55·0	39·7	110·
12	**29·812**	30·393	O.	C.B.	40·9	51·0	36·9	94·
13	29·679	30·256	B.HZ.	B.C.	44·4	54·0	34·5	106·
14	29·740	30·319	B.HZ.	B.	39·9	53·9	32·2	102·
15	29·590	30·166	B.HZ.	B.	41·9	53·9	32·5	104·
16	29·376	29·948	O.	C.B. to B.	39·2	54·5	37·2	102·
17	29·211	29·780	O.	C. to C.B. Th.R.	39·4	55·0	36·8	97·
18	29·061	29·628	F.	F. to R. to C.	44·2	59·0	41·0	113·
19	29·216	29·785	B.C.	C.B.	48·5	57·8	44·0	115·
20	29·430	30·003	C.B.	C.B.	49·3	59·5	45·0	113·
21	29·275	29·845	C.	C.B.	51·9	60·0	47·4	117·
22	29·302	29·873	C.	C. to R.	50·1	54·3	47·3	92·
23	28·993	29·557	C.	C.B.	51·0	**60·5**	48·8	**120**
24	29·069	29·635	C.	C. to R. to C.	49·4	56·0	40·0	107·
25	28·924	29·487	R.	R. to C.	44·1	47·5	42·0	51·
26	28·807	29·368	C.	C.	45·3	48·9	40·6	85·
27	29·021	29·586	R.	C.R.	45·5	52·9	43·1	102·
28	29·485	30·059	O.	C.	46·2	54·6	42·5	90·
29	29·575	30·150	B.	B. to B.C.	51·1	59·0	42·2	117·
30	29·630	30·207	B.C.	B.C. to C.	50·2	60·0	43·9	117·
Extreme Mean, or Sum.	**29·812** 28·807				44·0	**60·5**	28·4	**120**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
April 1	...	...	35	214	8·9	2·2	*5·5*	E.
2	...	...	...	449	18·7	3·0	*3·20*	N.E.
3	0·015	1	55	276	11·5	1·0	*2·5*	N.N.W.
4	...	...	...	245	10·2	1·0	1·25	E.N.E.
5	...	5	10	224	9·3	1·2	*3·35*	W.S.W.
6	0·050	...	...	**480**	**20·0**	**7·7**	*1·50*	W.S.W.
7	0·100	1	50	208	8·7	1·0	4·20	W.
8	...	0	55	270	11·2	1·8	*4·0*	S.W.
9	...	7	15	370	15·4	3·4	*4·30*	W.S.W.
10	...	6	25	416	17·3	3·0	11·10	W.
11	...	8	25	322	13·4	1·3	*3·25*	W.N.W.
12	...	2	30	249	10·4	0·6	*2·40*	N.W.
13	...	7	10	281	11·7	1·5	*4·55*	E.
14	...	11	20	399	16·6	2·0	*4·5*	E.
15	...	**12**	**20**	423	17·6	3·0	*11·20*	E.N.E.
16	...	5	40	443	18·5	2·0	12·30	E.N.E.
17	0·035	2	50	297	12·4	...	...	...
18	0·355	...	45	132	5·5	...	...	...
19	...	5	5	198	8·2	...	...	...
20	...	3	20	294	12·2	1·5	*9·20*	S.
21	0·165	2	45	382	15·9	2·6	11·35	S.S.W.
22	0·415	...	15	402	16·7	4·0	*9·0*	S.
23	...	5	30	345	14·4	2·0	12·35	S.S.W.
24	0·105	1	20	300	12·5	2·5	11·20	S.S.E.
25	**0·885**	...	...	218	9·1	1·5	*3·55*	W.
26	0·040	...	...	272	11·3	0·5	*1·35*	W.S.W.
27	0·185	...	50	373	15·5	1·5	*3·0*	N.N.W.
28	0·020	...	30	188	7·8	...	...	...
29	...	7	5	194	8·1	...	...	...
30	...	5	25	266	11·1	1·0	*11·30*	S.S.W.
Extreme Mean, or Sum.	2·370	107	10	9130	12·7	**7·7**	*1·50*	W.S.W.

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radia-tion. Max.
May 1	29·527	30·102	O.	R. to C.B.	47·8	50·7	39·5	82·9
2	**30·015**	30·600	B.C.Hz.	B.C.	47·5	55·4	37·1	99·9
3	30·002	30·587	B.C.Hz.	B.C.	51·3	61·0	38·4	109·6
4	29·996	30·580	C.	B.C.	45·6	59·4	41·2	110·2
5	29·867	30·449	B.	B.C.	45·5	59·4	36·0	108·9
6	29·802	30·383	B.	B.	53·2	69·0	43·1	115·8
7	29·758	30·338	B.	B.	54·3	67·0	44·4	113·7
8	29·502	30·077	B.C.	B.C.	55·0	67·0	43·0	119·7
9	29·459	30·033	B.Hz.	B.C. to C.	58·0	70·0	46·6	123·7
10	29·554	30·130	B.C.	B.	51·8	65·8	42·4	107·6
11	29·635	30·212	B.	B.	55·7	70·8	43·5	115·6
12	29·652	30·230	C.	C.	58·6	67·0	51·3	92·6
13	29·736	30·315	C.	B.C.	60·7	70·0	53·1	122·2
14	29·759	30·339	B.C.	B.C.	59·0	60·6	53·9	114·2
15	29·506	30·081	C.	C.B.	51·0	59·3	48·2	100·1
16	29·335	29·906	B.	B.C. to C.B.	47·4	52·8	42·0	106·2
17	29·194	29·762	C.	C.	39·7	45·0	36·4	74·2
18	29·107	29·674	O.	C.	44·4	50·8	44·1	65·1
19	29·107	29·674	O.	C.B. to C.	50·8	53·8	44·1	109·2
20	29·208	29·777	O.	O.	45·0	49·3	41·2	68·1
21	29·169	29·737	O.	C.	45·3	52·2	44·0	64·6
22	29·303	29·874	C.B.Hz.	Dark to O. to C.B.	52·0	60·9	45·2	102·1
23	29·383	29·955	C.B.Hz.	C.B.	54·6	66·6	52·2	121·1
24	29·346	29·917	C.	C.	55·6	65·3	48·0	113·1
25	29·429	30·002	C.B.Hz.	B.C. to R.	53·8	67·0	47·5	113·1
26	29·646	30·223	B.C.Hz.	B.C.	57·8	66·4	46·9	115·1
27	29·806	30·387	B.	B.C.	62·0	72·1	47·5	124·1
28	29·729	30·308	B.Hz.	B.C.	63·6	73·3	50·2	120·1
29	29·581	30·157	B.	B.	61·0	75·7	46·0	123·1
30	29·344	29·915	B.	B.toC.toTh.	69·5	**77·6**	53·3	**127·1**
31	29·203	29·772	C.B.	B.C.	60·3	67·0	57·6	123·1
Extreme	**30.015**				53·5	**77·6**	36·0	**127·1**
Mean, or Sum.	29·107							

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DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
May 1	**0·405**	1	25	326	13·6	2·5	11·40	N.N.W.
2	...	9	15	191	8·0	...	...	...
3	...	10	50	314	13·1	2·0	*4·5*	N.E.
4	...	6	40	283	11·8	1·0	4·35	E.
5	...	9	25	304	12·7	1·0	*5·30*	N.E.
6	...	12	0	424	17·7	3·0	*12·35*	E.N.E.
7	...	12	40	442	18·4	3·4	*4·25*	E.
8	...	11	25	314	13·1	2·0	*1·50*	E.S.E.
9	0·030	7	35	173	7·2	0·5	*9·35*	N.W.
10	...	12	35	204	8·5	...	...	...
11	...	13	0	139	5·8	...	...	...
12	...	1	50	185	7·7	...	...	...
13	...	7	55	199	8·3	0·6	*5·35*	N.W.
14	...	6	40	336	14·0	4·5	*9·40*	N.W.
15	...	1	45	**689**	**28·7**	**9·0**	8·35	N.W.
16	...	6	50	479	20·0	5·0	10·5	N.N.W.
17	...	...	...	533	22·2	4·0	9·35	N.N.W.
18	...	...	...	447	18·6	2·5	*12·30*	N.N.W.
19	...	2	5	398	16·6	1·5	*1·40*	N.N.E.
20	...	...	...	221	9·2	...	...	...
21	...	...	...	109	4·5	...	...	...
22	...	1	55	101	4·2	...	...	...
23	...	5	5	138	5·7	...	...	...
24	0·030	1	15	158	6·6	...	...	...
25	0·105	8	40	156	6·5	0·5	*5·30*	N.N.W.
26	...	6	35	164	6·8	...	...	...
27	...	7	35	123	5·1	...	...	...
28	...	9	50	150	6·2	...	...	...
29	...	**13**	**20**	150	6·2	...	...	...
30	...	7	40	181	7·5	2·0	*11·55*	S.S.W.
31	0·215	5	30	356	14·8	4·2	*4·35*	S.S.W.
Extreme Mean, or Sum.	0·820	201	20	8387	11·3	**9·0**	8·35	N.W.

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
June 1	29·245	29·814	C.	R.	55·0	59·0	50·2	94·7
2	29·318	29·899	B.C.	B.C. to C.	50·9	64·0	43·2	117·6
3	29·557	30·133	O.	O.	54·8	62·6	51·1	106·0
4	29·654	30·232	O.	O.	56·8	68·0	54·0	127·5
5	29·785	30·365	O.	O. to C.B.	55·5	62·8	53·0	102·9
6	29·794	30·374	O.	C.B.	51·4	65·3	48·5	115·8
7	29·750	30·330	B.C.	B.	56·1	71·9	47·8	117·2
8	29·657	30·235	B.	B.	63·1	75·5	47·8	120·0
9	29·496	30·071	B.	B. to B.C.	62·8	71·0	51·4	121·3
10	29·398	29·970	C.	B.C.	58·1	65·4	53·0	115·7
11	29·427	30·000	C.	C.B. to R.	55·6	63·1	46·9	121·3
12	29·476	30·050	C.B.	B.C.	49·7	59·2	42·9	110·9
13	29·632	30·209	C.	B.C.	52·3	64·4	43·6	118·3
14	29·547	30·122	B.C.	C.B.	53·1	62·1	41·4	114·6
15	29·672	30·250	B.C.	B.C.	52·1	61·7	38·9	114·0
16	29·521	30·096	B.C.	B.C.	58·0	68·7	42·2	126·0
17	29·392	29·964	B.C.Hz.	C.	51·4	62·9	42·9	96·4
18	29·190	29·758	C.	C.B. to R.	54·3	64·0	43·2	109·6
19	29·140	29·707	C.	B.C.	53·6	67·3	45·5	123·2
20	29·399	29·971	B.	B.C.	57·1	71·3	44·3	126·3
21	29·673	30·251	B.C.	B.C.	56·3	69·9	44·1	**131·7**
22	29·742	30·321	C.	B.C.	60·3	75·0	54·0	130·8
23	29·822	30·403	C.B.	C.B.	66·9	73·1	56·0	117·5
24	**29·880**	30·462	C.B.	B.C.	66·8	77·4	59·0	129·8
25	29·854	30·436	B.C.	B.	63·9	79·4	52·6	121·3
26	29·620	30·197	C.	C.to Th.&R.	68·8	**80·0**	60·1	130·9
27	29·367	29·939	O.	B.C.	63·6	70·9	55·9	129·8
28	29·342	29·913	B.C.	B.C. to C.	60·0	63·6	50·0	104·1
29	29·128	29·695	C.	C.B. to Th. & R.	57·8	68·0	54·4	125·3
30	29·125	29·692	C.	B.C.toC.&R.	56·4	65·9	50·0	123·2
Extreme Mean, or Sum.	**29·880** 29·125				57·4	**80·0**	38·9	**131·7**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
June 1	0·160	...	55	201	8·4	0·4	9·25	S.S.E.
2	...	4	20	85	3·5	...	...	...
3	...	...	15	133	5·5	...	...	...
4	...	1	10	123	5·1	...	...	...
5	...	...	30	251	10·5	1·0	*1·35*	N.E.
6	...	8	5	**390**	**16·2**	2·0	*5·50*	N.E.
7	...	12	0	350	14·6	1·0	*12·25*	N.E.
8	...	10	30	253	10·5	1·0	*5·35*	N.N.W.
9	...	**12**	**20**	300	12·5	1·0	*8·40*	N.N.W.
10	...	9	50	372	15·5	2·0	*5·30*	N.N.W.
11	0·120	5	10	301	12·5	2·5	*7·35*	W.N.W.
12	...	8	35	361	15·0	2·0	*2·50*	N.N.W.
13	...	7	0	174	7·2	...	...	...
14	...	5	0	263	11·0	2·0	*4·15*	N.
15	...	7	50	127	5·3	...	...	...
16	...	11	40	218	9·1	1·6	*4·50*	N.W.
17	...	1	30	140	5·8	...	...	...
18	...	3	35	195	8·1	...	...	...
19	...	5	30	157	6·5	...	...	...
20	...	11	0	203	8·5	**4·0**	*1·35*	W.
21	...	9	35	224	9·3	1·0	*5·35*	S.W.
22	0·005	3	30	225	9·4	1·0	*2·35*	W.S.W.
23	...	3	5	269	11·2	1·0	*4·25*	N.W.
24	...	4	40	220	9·2	1·0	11·15	N.N.W.
25	...	12	10	139	5·8	...	...	...
26	**0·275**	3	30	159	6·6	1·0	*5·30*	W.S.W.
27	0·010	9	30	235	9·8	1·5	*1·30*	W.N.W.
28	...	4	10	324	13·5	2·3	*5·25*	S.S.W.
29	0·200	2	0	228	9·5	1·5	*6·55*	S.W.
30	0·125	7	20	286	11·9	1·5	*1·40*	S.S.W.
Extreme Mean, or Sum.	0·895	186	15	6906	9 6	**4·0**	*1·35*	W.

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Sola Radia tion. Max
July 1	29·065	29·631	C.	C.B.R.	61·2	65·6	53·0	119·
2	28·916	29·479	C.	R.	54·6	65·8	49·5	117·
3	29·416	29·989	R.	C.R.	54·0	62·9	50·7	100·
4	29·661	30·239	C.	C.B.	53·6	61·1	49·6	112·
5	**29·710**	30·289	C.	C.B.	54·4	65·8	50·9	102·
6	29·676	30·255	C.B.	B.C.	60·4	71·4	49·2	114·
7	29·649	30·226	B.C.	B.C. to B.	63·6	74·0	52·2	**128·**
8	29·568	30·144	B.	B.C.	64·0	**75·5**	54·4	122·
9	29·458	30·032	C.B.	B.C.	63·2	71·5	55·4	126·
10	29·400	29·973	C.B.	B.C.	58·2	67·8	53·4	118·
11	29·339	29·910	C.	C.B. to R.	58·0	68·9	52·4	125·
12	29·108	29·675	C.	B.C.	52·9	61·8	49·3	114·
13	29·309	29·880	B.C.	B. to C.B.	56·9	65·5	47·5	127·
14	29·218	29·787	B.C.	C.B. to C.	58·5	62·9	51·9	123·
15	29·391	29·963	C.	C.	56·6	61·6	52·5	107·
16	29·377	29·949	C.	C.R. to C.	56·1	60·0	49·5	97·
17	29·279	29·849	O.	C.	57·7	72·0	55·4	109·
18	29·223	29·792	D.	R.	56·2	64·3	55·7	103·
19	29·011	29·576	C.	Th. & R.	53·0	61·7	52·7	120·
20	28·944	29·507	C.	R.	54·0	61·5	50·2	99·
21	28·910	29·473	C.	Th. & R.	57·3	60·0	50·0	119·
22	29·087	29·653	C.	C.B.R.	56·5	64·3	49·3	119·
23	29·311	29·882	B.C.Hz.	B.C. to R.	55·7	65·2	52·0	116·
24	29·050	29·615	C.	C.B.R.	60·3	69·8	51·9	120·
25	29·263	29·833	O.	C.B.	62·2	71·8	59·6	124·
26	29·258	29·828	O.	C.B.	62·6	73·1	60·7	123·
27	29·122	29·689	C.	C.B.	57·0	64·1	56·4	120·
28	29·077	29·644	O.	C.	57·1	61·7	53·0	83·
29	29·320	29·891	O.	B.C. to C.	54·8	59·4	50·8	112·
30	29·476	30·050	B.	C.B.	56·6	64·0	46·2	116·
31	29·487	30·061	Hz.	C.B.	55·0	64·5	50·7	115·
Extreme Mean, or Sum.	**29·710** 28·910				57·5	**75·5**	46·2	**128·**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
July 1	0·250	4	40	372	15·5	3·0	*1·0*	S.
2	0·720	1	40	373	15·5	3·0	*7·30*	W.S.W.
3	0·075	...	45	382	15·9	2·0	*5·0*	N.W.
4	...	4	55	273	11·4	0·6	*2·15*	N.N.W.
5	0·010	2	55	166	6·9	...	...	...
6	...	9	30	157	6·5	...	...	...
7	...	**12**	**20**	187	7·8	...	...	...
8	...	11	10	221	9·2	3·3	*1·35*	S.S.W.
9	...	10	35	348	14·5	3·0	*6·30*	W.S.W.
10	...	8	15	256	10·7	2·0	12·35	W.S.W.
11	0·060	2	35	244	10·2	4·0	*11·5*	W.
12	0·250	8	25	**568**	23·6	**5·0**	*12·5*	N.W.
13	...	8	30	332	13·8	3·4	*11·45*	N.W.
14	...	5	35	488	20·3	5·0	*3·50*	W.N.W.
15	...	...	45	327	13·6	1·8	8·10	N.W.
16	0·025	...	10	313	13·0	1·9	*6·40*	S.W.
17	0·010	...	30	238	9·9	·5	*12·30*	S.
18	0·150	...	...	158	6·6	...	...	...
19	**0·795**	2	45	277	11·5	4·0	*12·25*	S.W.
20	0·160	...	10	289	12·0	1·5	9·10	S.
21	0·175	1	45	228	9·5	1·0	*12·50*	W.
22	0·060	5	10	287	12·0	2·0	*2·25*	W.N.W.
23	0·025	5	20	240	10·0	1·0	*1·25*	W.
24	0·375	2	5	351	14·6	2·5	9·40	W.
25	0·035	2	50	411	17·1	4·0	*12·50*	S.W.
26	0·010	3	20	311	13·0	1·0	11·35	S.
27	0·070	2	5	346	14·4	2·0	*5·40*	S.W.
28	...	...	...	179	7·5	...	...	...
29	...	3	10	248	10·3	0·5	4·15	N.W.
30	...	3	45	220	9·2	...	...	...
31	...	2	40	168	7·0	...	...	...
Extreme Mean, or Sum.	3·255	128	30	8958	12·0	**5·0**	*12·5*	N.W.

Ital. = P.M.

Small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Ha

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Sol. Radi tion Ma
Aug. 1	29·454	30·028	O.	C.	58·2	64·8	48·5	109
2	29·102	29·669	C.B.	C.B.Th.R.	59·3	65·3	52·1	116
3	28·953	29·517	C.	C.R.	55·1	58·8	52·3	103
4	28·758	29·318	C.B.	C.B.R.	55·4	61·1	48·3	122
5	28·930	29·493	C.B.	C.B. to R.	56·3	61·0	48·9	109
6	28·910	29·473	C.B.	C.B.	54·1	62·0	51·9	112
7	29·191	29·759	C.	C.B.	56·5	63·3	49·9	118
8	29·298	29·868	B.C.	B.C.toC.toR	57·3	64·9	46·6	118
9	29·099	29·665	C.	C.B.	62·4	69·0	52·6	125
10	29·208	29·777	C.B.	B.C.to C.to**R**	59·2	68·0	54·0	120
11	28·900	29·463	R.	C. & R.	55·7	63·4	53·9	124
12	29·166	29·734	C.	C.B.	54·9	64·4	49·6	118
13	29·171	29·738	R.	C.	51·8	63·0	50·6	105
14	29·349	29·920	C.B.	C.B.R.	57·3	66·0	52·0	123
15	29·647	30·224	Hz.	O.	57·6	64·6	51·5	92
16	29·652	30·230	O.	C. to C.B.	61·2	**75·0**	58·0	130
17	29·640	30·217	B.c.	B.C.	63·0	**75·0**	59·8	**130**
18	29·570	30·146	B.c.	B.C.	65·2	**75·0**	53·5	125
19	29·500	30·075	B.c.Hz.	B.C.	63·4	73·9	55·2	126
20	29·540	30·115	C.B.	B.C.	61·3	68·2	57·3	124
21	29·488	30·062	C.B.	B.C.	61·1	72·2	51·9	124
22	29·265	29·835	O.	C.B.	64·8	74·8	60·6	119
23	29·265	29·835	C.B.	C.B.R.	62·5	70·2	55·8	129
24	29·367	29·938	C.B.	C.B.R.	55·9	63·7	50·0	114
25	**29·686**	**30·264**	B.C.	C.B.	54·0	63·2	44·7	121
26	29·480	30·054	R.	C.R.	57·2	63·3	53·2	85
27	29·164	29·732	C.	C.B.R.	60·4	66·5	55·2	119
28	29·550	30·126	C.B.	C.B.	59·2	67·0	51·3	124
29	29·589	30·165	C.	C. to B.C.	59·0	68·5	53·2	121
30	29·465	30·039	B.C.	B.C.	59·6	67·0	53·6	126
31	29·617	30·194	B.C.	B.C.	55·9	64·7	49·2	122
Extreme Mean, or Sum.	**29·686** 28·758				58·5	**75.0**	44·7	**130**

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Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Aug. 1	0·020	1	10	211	8·8	...	...	...
2	0·225	2	25	250	10·4	1·0	4·30	S.
3	0·050	...	40	280	11·7	1·5	*12·30*	S.W.
4	0·040	6	10	243	10·1	1·5	10·10	W.
5	0·110	2	0	273	11·4	1·0	10·15	W.
6	0·550	1	35	389	16·2	3·0	*2·50*	W.N.W.
7	0·010	3	20	217	9·0	1·0	*12·5*	W.N.W.
8	0·050	6	30	173	7·2	...	...	...
9	0·045	5	20	317	13·2	3·0	*1·30*	W.S.W.
10	0·450	4	5	229	9·5	1·0	*5·35*	S.
11	0·160	3	25	441	18·4	5·0	*12·15*	S.S.W.
12	0·040	5	10	337	14·0	2·0	*3·40*	S.S.W.
13	**0·560**	1	0	183	7·6	...	...	...
14	0·015	4	20	333	13·9	1·8	*2·40*	W.N.W.
15	0·005	...	...	118	4·9	...	...	...
16	0·005	5	25	124	5·2	...	...	...
17	...	7	20	182	7·6	0·6	*2·35*	S.
18	...	10	10	206	8·6	0·5	*12·10*	S.
19	...	9	50	164	6·8	...	...	...
20	...	5	45	171	7·1	...	...	...
21	...	**11**	**15**	205	8·5	0·6	*12·35*	S.S.W.
22	0·020	2	45	195	8·1	1·5	*3·30*	S.W.
23	0·030	6	20	295	12·3	1·4	*1·20*	S.W.
24	0·020	3	10	309	12·9	2·0	*5·35*	N.W.
25	...	5	55	273	11·4	1·2	*11·25*	S.S.W.
26	0·120	...	...	400	16·7	3·0	*6·30*	S.W.
27	0·200	4	35	**480**	**20·0**	**5·5**	*2·35*	W.
28	...	5	30	308	12·8	3·0	*3·5*	W.
29	...	4	45	375	15·6	3·0	*5·20*	W.S.W.
30	0·025	10	0	413	17·2	4·6	*2·20*	W.
31	...	4	30	263	11·0	0·5	5·50	W.
Extreme Mean, or Sum.	2·750	144	25	8357	11·2	**5·5**	*2·35*	W.

Ital. = P.M.

Small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation Max.
Sept. 1	29·527	30·102	B.	B.	55·6	72·0	45·2	116·
2	29·315	29·886	B.	B.	60·8	73·9	52·1	122·
3	29·448	30·021	B.Hz.	B.C. to Th. to C.	60·4	69·4	53·1	122·
4	29·527	30·102	B.C.	C.B.	58·3	67·6	51·1	116·
5	29·456	30·029	C.	C.	57·4	64·8	51·5	98·
6	29·517	30·092	C.	C.B.	60·2	68·3	55·6	124·
7	29·384	29·956	C.B.	C.B.	60·7	69·8	56·9	124·
8	29·665	30·243	B.Hz.	B.	57·3	72·5	49·9	118·
9	29·548	30·123	B.	B.	63·7	80·0	53·3	**129·**
10	29·298	29·868	Hz.	C.B.R.	62·4	70·7	54·0	121·
11	29·133	29·700	C.	C.B.	56·1	61·7	50·5	116·
12	29·442	30·015	C.	C.	54·3	58·3	51·9	103·
13	29·648	30·225	C.	C.B.	53·8	61·2	49·6	103·
14	29·674	30·252	Hz.	B.Hz.	53·1	63·0	45·0	94·
15	29·757	30·337	Hz.	Hz. to C.	53·5	67·4	46·1	95·
16	29·705	30·284	Hz.	B.	58·1	70·9	50·2	114·
17	29·612	30·189	C.	C. to B.C.	51·0	69·8	47·6	111·
18	29·478	30·052	B.	B.	56·3	72·8	49·8	119·
19	29·579	30·155	C.	C.	53·3	60·9	51·3	94·
20	**29·845**	30·426	F.	B.C.	48·0	64·9	44·4	109·
21	29·815	30·396	B.	B.C.	52·4	63·1	43·4	114·
22	29·778	30·358	B.M.	B.C.	47·4	68·0	40·4	112·
23	29·676	30·254	B.	B.C.	57·8	77·2	46·0	121·
24	29·630	30·207	B.	B.	63·2	**81·8**	56·3	119·
25	29·624	30·201	B.C.	B.C.	67·9	80·8	60·6	119·
26	29·722	30·301	C.	B.C.	65·0	79·8	57·3	128·
27	29·673	30·251	B.Hz.	B.	65·2	80·9	57·8	117·
28	29·686	30·264	B.	B.	64·5	80·1	56·4	117·
29	29·681	30·259	B.Hz.	B.	64·3	75·3	52·0	115·
30	29·525	30·100	M.	C. to B.	54·5	70·0	53·6	103·
Extreme Mean, or Sum.	**29.845** 29·133				57·8	**81·8**	40·4	**129·**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Sept. 1	...	**11**	**40**	191	8·0	...	...	...
2	...	10	15	228	9·5	1·0	*4·0*	W.
3	0·050	4	30	202	8·4	1·5	*10·30*	N.N.W.
4	...	5	10	265	11·0	1·5	*2·35*	W.S.W.
5	0·005	...	10	291	12·1	1·8	11·50	S.S.W.
6	...	3	5	130	5·4	...	...	...
7	0·140	4	35	184	7·7	1·0	12·30	S.
8	...	9	40	116	4·8	...	...	...
9	...	10	45	253	10·5	2·0	*1·5*	S.S.E.
10	**0·190**	2	20	281	11·7	2·0	*1·10*	S.S.W.
11	0·010	4	55	**502**	**20·9**	**5·5**	*12·35*	W.
12	...	...	30	370	15·8	2·0	*2·35*	W.N.W.
13	...	3	35	260	10·8	2·0	10·50	N.N.W.
14	...	8	20	173	7·2	...	...	...
15	...	2	30	87	3·6	...	...	...
16	...	9	50	164	6·8	...	...	...
17	...	6	0	273	11·4	1·5	*3·0*	S.W.
18	...	9	25	308	12·8	2·5	*1·0*	W.S.W.
19	0·030	1	15	242	10·1	1·0	*3·25*	N.
20	...	6	10	124	5·2	...	...	...
21	...	6	5	171	7·1	...	...	...
22	...	7	5	132	5·5	...	...	...
23	...	10	5	152	6·3	...	...	...
24	0·030	9	50	160	6·6	...	...	...
25	...	8	30	177	7·4	...	...	...
26	...	5	25	156	6·5	...	...	...
27	...	9	0	168	7·0	...	...	...
28	...	9	20	159	6·6	...	...	...
29	...	10	0	175	7·3	0·5	16·0	E.S.E.
30	...	4	40	184	7·7	...	...	...
Extreme Mean, or Sum.	0·455	194	40	6278	8·7	**5·5**	*12·35* Ital. = P.M.	W.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail.

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Oct. 1	29·204	29·773	C.	C. to R.	56·1	**70·0**	52·9	**111·2**
2	28·825	29·386	C.	C.B.R.	47·3	62·5	39·2	108·9
3	28·745	29·304	C.	C.B.R.	48·6	59·0	37·6	109·7
4	28·769	29·329	C.	C.B.	51·0	53·1	42·4	100·5
5	29·164	29·732	C.	C. to R.	49·0	55·7	39·7	78·8
6	29·033	29·598	O.	C.	51·5	56·3	48·3	74·1
7	29·131	29·698	B.	B.C. to C.	47·5	56·3	41·9	106·0
8	28·798	29·358	R.	R.C.	49·3	55·2	46·9	73·4
9	28·643	29·200	O.	C.	48·0	51·8	46·3	70·5
10	29·082	29·648	C.	C.	47·2	52·6	43·1	89·0
11	29·505	30·080	C.	C.	48·6	53·0	41·6	82·8
12	29·511	30·086	C.	C.B.	51·2	56·5	48·6	91·2
13	29·618	30·195	C.	C.	52·1	54·6	49·6	73·5
14	29·448	30·021	O.	C.	50·3	52·4	49·0	66·6
15	29·390	29·962	C.B.	C.B.	50·3	61·1	47·6	105·9
16	29·608	30·185	C.B.	C.	44·0	55·0	42·4	81·5
17	29·934	30·517	B.C.	B. to C.B.	40·6	49·4	33·6	81·0
18	**29·966**	30·549	F.	B.C.	35·0	53·9	33·6	94·9
19	29·839	30·420	O.	C.	44·6	54·6	38·5	101·0
20	29·684	30·262	O.	O.	48·9	50·0	44·2	63·9
21	29·501	30·076	O.	O. to R.	44·1	48·7	43·0	68·0
22	29·246	29·815	R.	R. to C.	38·0	45·2	34·8	50·7
23	29·101	29·668	B.	B.C.	33·7	43·1	30·8	81·5
24	28·927	29·490	C.	C.B.	33·8	44·0	28·6	90·7
25	28·922	29·485	B.	B. to C.B.	35·4	44·0	30·9	80·1
26	29·015	29·580	M.	C.	31·3	38·8	28·8	54·9
27	29·139	29·706	M.	C.B.	33·4	42·2	30·8	74·0
28	29·151	29·719	B.	C.B.	33·2	41·3	29·8	84·8
29	29·268	29·838	M.	C.	31·0	37·8	30·0	58·8
30	29·543	30·118	C.	C. to R.	36·7	44·4	31·1	84·9
31	29·282	29·852	O.	O.	43·3	46·3	38·9	68·5
Extreme Mean, or Sum.	**29·966** 28·643				43·7	**70·0**	28·6	**111·2**

NOTE.—Heavy type indicates maximum or in large quantities.

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Oct. 1	**0·580**	2	0	209	8·7	1·5	*10·50*	S.
2	0·240	4	25	449	18·7	9·4	4·10	W.
3	0·110	2	30	**491**	**20·5**	**14·5**	*3·20*	W.
4	0·025	4	25	440	18·3	5·0	*3·30*	N.W.
5	0·225	...	45	331	13·8	2·5	*8·50*	S.S.W.
6	0·110	...	...	135	5·6	...	...	...
7	0·010	5	10	277	11·5	1·2	*2·20*	W.S.W.
8	0·200	...	...	257	10·7	0·8	*3·30*	E.
9	0·470	...	...	413	17·2	2·0	*1·35*	N.W.
10	...	1	40	335	14·0	2·0	10·20	N.N.W.
11	...	...	40	323	13·5	2·8	10·35	N.W.
12	...	1	35	403	16·8	5·0	10·55	W.N.W.
13	...	...	...	246	10·2	1·0	*1·25*	W.
14	...	...	...	172	7·2	0·5	10·20	S.W.
15	...	3	55	156	6·5	...	...	...
16	0·145	1	10	294	12·2	1·5	1·25	N.E.
17	...	3	0	206	8·6	0·5	11·10	E.N.E.
18	...	3	30	133	5·5	...	...	...
19	...	...	20	77	3·2	...	...	...
20	...	...	...	93	3·9	...	...	...
21	0·200	...	...	142	5·9	1·2	*11·20*	N.E.
22	0·320	...	...	437	18·2	2·3	8·20	N.E.
23	...	**5**	**55**	293	12·2	1·0	*12·25*	N.N.E.
24	0·020	3	50	254	10·6	1·0	*3·30*	W.
25	...	4	40	235	9·8	...	...	...
26	...	...	...	245	10·2	1·0	*1·50*	N.N.W.
27	0·015	3	20	171	7·1	...	...	...
28	...	3	25	197	8·2	...	...	...
29	...	...	...	303	12·6	1·0	*5·20*	N.N.W.
30	0·140	...	...	302	12·6	1·0	*6·25*	S.W.
31	...	...	...	253	10·5	0·5	*7·50*	E.N.E.
Extreme Mean, or Sum.	2·810	56	15	8272	11·1	**14·5**	*3·20*	W.

Ital. = P.M.

small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at th

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Tempera-ture.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radia-tion. Max
Nov. 1	**29·843**	30·424	O.	O.	43·5	49·6	41·8	67·
2	29·743	30·322	O.	C.	44·2	50·1	42·6	84·
3	29·399	29·971	F.	O.	36·9	46·0	34·3	48·
4	29·200	29·769	F.	O. to R.	41·4	44·0	39·1	43·
5	28·949	29·512	M.	R.	41·0	52·8	38·9	55·
6	28·736	29·295	C.B.	C.B.	53·8	55·7	48·3	85·
7	29·261	29·831	O.	R.	48·9	54·0	48·0	59·
8	29·348	29·919	O.	C. to R.	50·0	53·0	48·0	63·
9	29·140	29·707	C.	C.B.	47·0	53·0	43·6	95·
10	28·987	29·551	C.	R.	52·0	55·0	41·0	61·
11	28·636	29·193	B.C.	B.C.toC.&R.	46·0	55·0	41·3	**95·**
12	28·554	29·109	R.	C.B.	42·5	50·3	39·0	89·
13	28·915	29·478	B.	B.C.	45·2	51·8	40·8	95·
14	29·134	29·701	B.C.	B.R.	43·4	50·8	40·1	91·
15	29·348	29·919	C.	C. to R.	41·2	57·0	37·4	59·
16	28·926	29·489	C.	C.	57·9	**59·4**	40·8	66·
17	29·226	29·795	B.C.	B.C.	41·6	48·7	39·2	92·
18	29·751	30·331	M.	B.C.	35·1	48·5	33·5	88·
19	29·611	30·188	B.	C.B. to C.	36·2	44·9	34·1	79·
20	29·291	29·861	O.	O. to R.	46·0	48·4	41·2	49·
21	29·426	29·999	F.	C.	45·1	48·8	45·0	51·
22	29·613	30·190	C.	C.B.toC.&R.	50·0	54·0	42·5	90·
23	29·338	29·909	B.	C.	34·4	43·2	33·7	56·
24	29·765	30·345	C.	C.	39·4	41·8	36·0	76·
25	29·738	30·317	C.	C.	41·0	42·0	40·0	49·
26	29·594	30·170	O.	O.	39·8	40·8	35·0	41·
27	29·398	29·970	D.	C.R.	38·0	43·4	34·8	43·
28	29·279	29·849	M.	C.R.	43·2	44·5	42·5	47·
29	29·089	29·655	O.	R.	48·5	49·8	44·5	52·
30	29·051	29·617	O.	C.	46·2	49·8	41·8	56·
Extreme Mean, or Sum.	**29·843** 28·554				44·0	**59·4**	33·5	**95·**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Nov. 1	0·010	...	...	267	11·1	0·5	1·35	E.N.E.
2	...	1	5	338	14·1	3·0	*1·35*	E.
3	...	...	...	92	3·9	...	...	...
4	0·115	...	...	156	6·5	...	...	...
5	0·500	...	...	332	13·8	6·0	*9·50*	W.S.W.
6	0·105	1	20	688	28·6	10·0	11·25	W.S.W.
7	0·165	...	...	308	12·8	2·0	2.5	W.S.W.
8	0·040	...	...	165	6·9	...	...	...
9	0·170	3	15	251	10·5	1·5	*12·30*	W.
10	**0·570**	...	...	651	27·1	**15·0**	*11·30*	S.W.
11	0·120	4	45	411	17·1	13·0	12·20	S.W.
12	0·075	4	30	390	16·2	1·7	7·25	S.S.W.
13	...	5	0	400	16·7	4·1	*12·30*	W.
14	0·280	4	25	389	16·2	4·7	*1·20*	W.
15	0·260	...	...	493	20·5	10·7	*5·30*	S.S.W.
16	0·065	...	...	708	29·5	19·0	*6·25*	W.N.W.
17	0·035	4	15	301	12·5	1·5	2·55	S.W.
18	...	**5**	**25**	203	8·5	...	...	...
19	0·010	1	50	322	13·4	1·9	*9·25*	S.E.
20	0·120	...	...	347	14·5	2·0	10·10	S.E.
21	0·010	...	...	265	11·0	0·5	8·30	E.S.E.
22	0·080	1	10	296	12·3	1·5	*8·20*	N.W.
23	0·080	...	...	546	22·7	4·5	*12·25*	N.N.E.
24	...	...	50	558	23·3	6·6	*9·25*	E.N.E.
25	...	...	...	622	25·9	5·8	*12·55*	E.N.E.
26	...	...	...	414	17·2	3·0	6·40	E.N.E.
27	0·110	...	...	190	7·9	...	...	...
28	0·190	...	...	206	8·6	...	...	...
29	0·285	...	...	346	14·4	2·0	*12·5*	E.S.E.
30	0·030	...	...	341	14·2	3·0	*1·10*	N.W.
Extreme Mean, or Sum.	3·415	37	50	10996	15·3	**15·0**	*11·30*	S.W.

Ital. = P.M.

Small type indicates minimum or in small quantities.

Daily Results of Meteorological Observations made at the

NOTE.—B. = Blue Sky. C. = Clouds. D. = Drizzling Rain. F. = Fog. H. = Hail

DATE.	BAROMETER READINGS AT 9 A.M.		WEATHER.		TEMPERATURE.			
1895.	Corrected for Temperature.	Corrected to Sea Level.	At 9 a.m.	Generally during day.	At 9 a.m.	Highest.	Lowest.	Solar Radiation. Max.
Dec. 1	29·395	29·963	B.C.	C.B.	37·6	46·0	36·1	80·
2	29·535	30·110	C.B.	C.	38·8	45·9	36·5	57·
3	29·405	29·978	C.B.	C.B.	44·1	49·6	39·2	81·
4	29·389	29·961	C.	C.	43·3	50·2	37·8	63·
5	28·970	29·534	C.	C.R.	52·0	**53·8**	44·0	57·
6	28·825	29·386	C.B.	C.B.R.	41·4	48·4	33·1	75·
7	29·014	29·579	B.C.	B.C. to Sleet.	32·4	36·2	31·3	86·
8	29·497	30·071	C.B.	C.B.	34·0	37·8	30·5	74·
9	29·330	29·901	O.	C.	40·0	48·0	32·0	56·
10	29·336	29·907	C.B.	C.B.	37·2	47·5	35·2	75·
11	29·423	29·996	O.	C. to R.	36·5	40·8	30·6	54·
12	29·146	29·713	M.	C. to R.	33·8	44·6	32·0	46·
13	28·713	29·272	B.C.	C.	37·4	41·1	33·2	65·
14	29·170	29·738	B.C.	C. to R.	38·6	47·0	35·7	47·
15	28·584	29·140	C.	B.C.	44·3	49·4	34·3	82·
16	28·416	28·969	C.	C.	39·4	40·8	34·4	54·
17	28·944	29·507	D.	C.	38·5	41·2	33·6	61·
18	29·189	29·757	O.	C.R.	34·0	40·1	33·4	39·
19	29·298	29·868	O.	C.	34·0	36·8	33·0	53·
20	29·414	29·988	O.	C.	32·7	35·1	31·5	39·
21	29·373	29·945	F.	C.	32·2	34·4	26·2	37·
22	29·221	29·790	C.B.	C.B. to C.	29·4	33·6	25·9	57·
23	29·151	29·719	O.	C.	32·6	35·3	32·0	42·
24	28·909	29·472	O.	C. to R.	35·6	36·0	34·1	36·
25	29·103	29·670	O.	O.	30·6	35·1	29·6	35·
26	29·298	29·968	O.	O.	29·3	31·7	28·0	33·
27	29·672	30·250	O.	O.	32·0	32·7	31·0	37·
28	**29·702**	30·281	O.	R.	31·0	44·5	30·0	44·
29	29·320	29·890	C.	C. to R.	45·2	47·0	43·0	56·
30	29·105	29·672	O.	C.	49·0	53·7	45·5	**88·**
31	29·309	29·880	C.	C.	46·4	49·7	45·8	67·
Extreme Mean, or Sum.	**29·702** 28·416				37·5	**53·8**	25·9	**88·**

NOTE.—Heavy type indicates maximum or in large quantities

Birmingham and Midland Institute Observatory, Edgbaston.

Hz. = Hazy. M. = Mist. O. = Overcast. R. = Rain. S. = Snow. Th. = Thunder.

DATE.	RAIN.	SUNSHINE.		HORIZONTAL MOTION OF THE AIR.		EXTREME PRESSURE OF THE WIND ON THE SQUARE FOOT.		
1895.	Inches.	Hours.	Minutes.	Miles.	Mean Hourly.	Amount, pounds.	Time, hours.	Direction.
Dec. 1	...	4	5	287	12·0	1·0	*12·50*	W.S.W.
2	...	...	40	305	12·7	1·5	*8·30*	S.W.
3	0·025	2	30	407	17·0	6·0	2·10	W.S.W.
4	...	...	20	550	22·9	13·0	*10·25*	W.
5	0·055	...	...	**817**	**34·0**	**13·0**	*1·40*	W.
6	*0·070*	3	0	670	27·9	11·0	*1·50*	W.N.W.
7	*0·070*	2	30	596	24·8	13·0	1·25	W.N.W.
8	*0·010*	1	20	304	12·7	1·5	2·25	N.W.
9	...	...	...	388	16·2	5·0	*4·30*	W.
10	...	4	25	238	9·9	...	...	...
11	0·095	...	...	180	7·5	...	...	...
12	**0·445**	...	...	428	17·8	7·5	*5·40*	W.
13	0·030	1	0	753	31·4	10·0	11·0	W.N.W.
14	0·115	...	...	305	12·7	1·5	*1·35*	N.W.
15	0·210	**4**	**45**	427	17·8	4·0	12·0 noon	S.W.
16	0·050	...	...	378	15·7	2·5	10·20	S.
17	0·015	...	...	287	12·0	1·0	*7·0*	E.
18	0·025	...	...	382	15·9	1·8	3·35	E.
19	...	...	...	219	9·1	...	...	...
20	...	...	...	186	7·7	...	...	...
21	...	...	...	114	4·7	...	...	...
22	...	1	10	273	11·4	...	...	...
23	...	...	...	486	20·3	3·4	*8·20*	E.S.E.
24	0·220	...	...	610	25·4	7·0	11·20	E.S.E.
25	*0·050*	...	...	520	21·7	4·0	10·20	E.
26	*0·010*	...	...	433	18·0	2·0	1·20	E.
27	...	...	...	307	12·8	...	...	...
28	0·170	...	...	306	12·7	1·0	*3·25*	S.S.E.
29	0·020	...	...	200	8·3	...	...	...
30	0·235	...	25	285	11·9	3·0	*12·25*	W.
31	0·070	...	...	182	7·6	...	...	...
Extreme or Mean, or Sum.	1·990 Ital. = Snow melted.	26	10	11823	15·9	**13·0**	*1·40* Ital. = P.M.	W.

small type indicates minimum or in small quantities.

EDGBASTON METEOROLOGICAL OBSERVATORY.

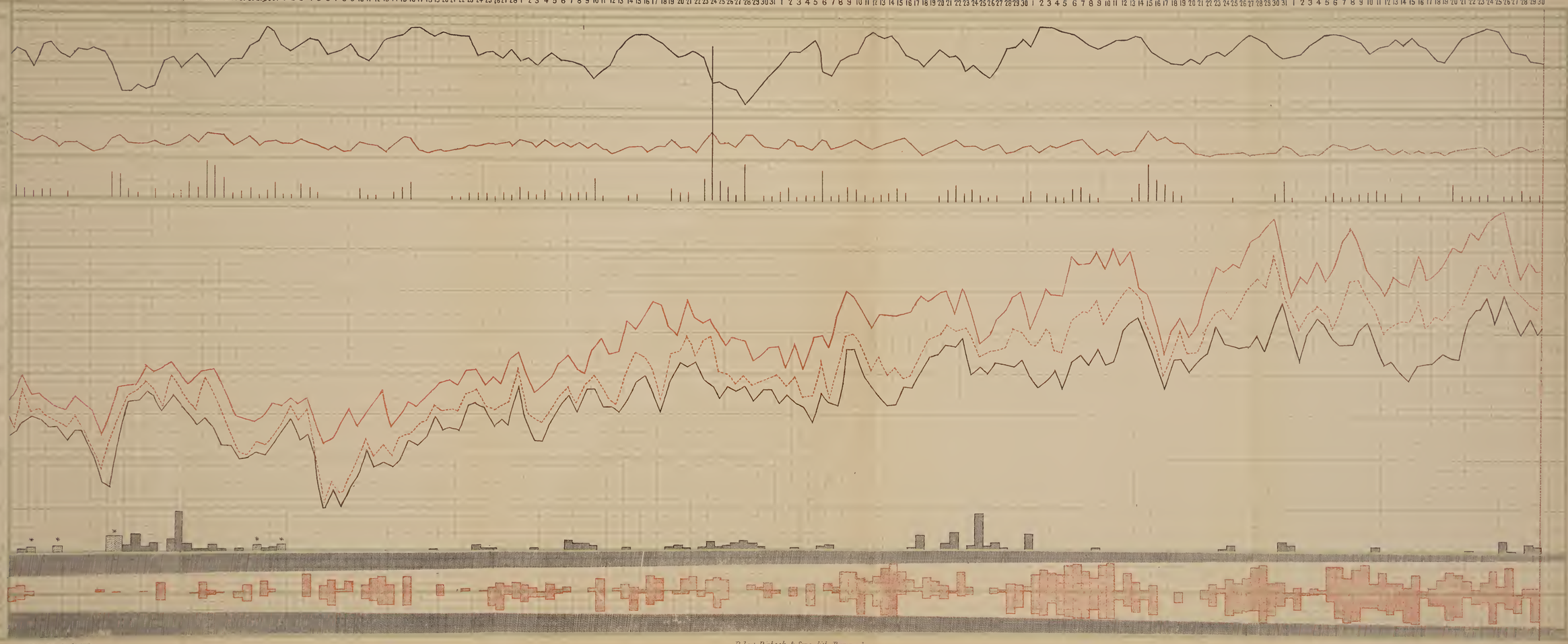
Comparison of Maxima, Minima, and Means for each month of 1895, with the Average for the same month for the past Eight Years.

The Large Type is for 1895. The Small Type underneath, the corresponding figure for the past Eight Years.

DATE.	BAROMETER.						TEMPERATURE.							SUNSHINE.	RAIN.	WIND.			DATE.
1895.	Mean of 9 a.m. Readings.	Mean corrected to Sea Level.	Highest.	Date of Highest Reading.	Lowest.	Date of Lowest Reading.	Mean 9 a.m. Readings.	Maximum.	Date of Maximum.	Minimum.	Date of Minimum.	Solar Radiation Maximum.	Date of Solar Radiation Max.	Total Hours and Minutes.	Total Inches.	Total Velocity in Miles.	Extreme Pressure in lbs. per sq. ft.	Date of Extreme Pressure.	1895.
														H. M.					
JANUARY, 1895 ...	29·109	29·676	29·901	30th	28·344	13th	30°·0	42°·8	19th	13°·9	12th	70°·0	18th	25—20	3·920	10204	9·0	23rd	JANUARY, 1895.
Do. Past 8 Years	29·416	29·981	30·120	3rd, 1889	28·004	23rd, 1890	36°·4	58°·0	10th, 1888	10°·8	5th, 1894	86°·6	31st, 1893	40—24	1·528	10115	20·0	26th, 1888	Do. Past 8 Years.
FEBRUARY, 1895 ...	29·516	30·091	29·886	17th	29·108	11th	26°·0	43°·6	28th	8°·0	6th	89°·8	28th	58—10	0·320	7653	4·0	16th	FEBRUARY, 1895.
Do. Past 8 Years	29·444	30·009	30·126	7th, 1887	28·199	21st, 1893	37°·1	61°·9	28th, 1891	15°·6	17th, 1892	98°·2	17th, 1894	53— 5	1·202	9663	27·5	11th, 1894	Do. Past 8 Years.
MARCH, 1895	29·113	29·680	29·762	16th	28·140	28th	38°·7	58°·1	21st	24°·0	4th	103°·0	11th	75—15	1·910	9948	37·0	24th	MARCH, 1895.
Do. Past 8 Years	29·328	29·899	30·041	30th, 1892	28·133	11th, 1888	39°·4	64°·8	29th, 1893	21°·3	4th, 1890	111°·2	31st, 1894	95—58	1·440	10075	19·0	23rd, 1887	Do. Past 8 Years.
APRIL, 1895	29·317	29·888	29·812	12th	28·807	26th	44°·0	60°·5	23rd	28°·4	5th	120°·0	23rd	107—10	2·370	9130	7·7	6th	APRIL, 1895.
Do. Past 8 Years	29·345	29·916	30·080	17th, 1887	28·533	4th, 1889	44°·3	79°·0	20th, 1893	27°·0	14th, 1892	125°·7	21st, 1893	115—47	1·534	8895	12·0	1st, 1887	Do. Past 8 Years.
MAY, 1895	29·538	30·113	30·015	2nd	29·107	19th	53°·5	77°·6	30th	36°·0	5th	127°·2	30th	201—20	0·820	8386	9·0	15th	MAY, 1895.
Do. Past 8 Years	29·296	29·866	29·890	11th, 1888	28·656	1st, 1888	50°·8	77°·4	28th, 1892	31°·0	17th, 1891	132°·3	31st, 1892	134—53	2·270	9414	18·0	20th, 1887	Do. Past 8 Years.
JUNE, 1895	29·520	30·095	29·880	24th	29·125	30th	57°·4	80°·0	26th	38°·9	15th	131°·7	21st	186—15	0·895	6906	4·0	20th	JUNE, 1895.
Do. Past 8 Years	29·448	30·021	29·870	30th, 1887	28·663	30th, 1890	57°·2	82°·8	16th, 1893	38°·3	1st, 1890	131°·8	10th, 1892	146—22	1·963	8056	6·5	28th, 1893	Do. Past 8 Years.
JULY, 1895	29·293	29·863	29·710	5th	28·910	21st	57°·5	75°·5	8th	46°·2	30th	128°·0	7th	128—30	3·255	8958	5·0	12th	JULY, 1895.
Do. Past 8 Years	29·359	29·931	29·850	1st, 1889	28·717	1st, 1890	58°·7	84°·6	4th, 1887	39°·5	11th, 1888	138°·0	2nd, 1893	122— 0	2·449	8751	11·0	19th, 1892	Do. Past 8 Years.
AUGUST, 1895 ...	29·322	29·893	29·686	25th	28·758	4th	58°·5	75°·0	15th 16th 17th	44°·7	25th	130°·9	17th	143—25	2·750	8357	5·5	27th	AUGUST, 1895.
Do. Past 8 Years	29·328	29·899	29·796	3rd, 1887	28·636	20th, 1889	58°·3	85°·6	18th, 1893	41°·2	14th, 1887	131°·7	18th, 1893	130—30	2·998	8795	12·0	26th, 1891	Do. Past 8 Years.
SEPTEMBER, 1895 ...	29·579	30·155	29·845	20th	29·133	11th	57°·8	81°·8	24th	40°·4	22nd	129°·0	9th	194—40	0·455	6278	5·5	11th	SEPTEMBER, 1895.
Do. Past 8 Years	29·413	30·016	29·918	24th, 1887	28·494	2nd, 1887	51°·3	80°·5	11th, 1891	33°·0	29th, 1887	127·9	5th, 1893	106—42	1·872	8241	12·0	1st, 1891	Do. Past 8 Years.
OCTOBER, 1895 ...	29·258	29·828	29·966	18th	28·643	9th	43°·7	70°·0	1st	28°·6	24th	111°·2	1st	56—15	2·810	8272	14·5	3rd	OCTOBER, 1895.
Do. Past 8 Years	29·306	29·877	30·096	31st, 1891	28·440	25th, 1894	46°·5	65°·6	13th, 1890	27°·9	28th, 1890	112°·0	16th, 1893	74—49	2·664	9056	17·0	7th, 1889	Do. Past 8 Years.
NOVEMBER, 1895 ...	29·276	29·846	29·843	1st	28·554	12th	44°·0	59°·4	16th	33°·5	18th	95°·3	11th	37—50	3·415	10996	15·0	10th	NOVEMBER, 1895.
Do. Past 8 Years	29·321	29·892	30·069	5th, 1891	27·813	11th, 1891	42°·3	61°·6	9th, 1889	23°·5	27th, 1890	97°·9	2nd, 1894	39—- 5	2·355	9559	19·0	24th, 1888	Do. Past 8 Years.
DECEMBER, 1895 ...	29·198	29·756	29·702	28th	28·416	16th	37°·5	53°·8	5th	25°·9	22nd	88°·0	30th	26—10	1·990	11823	13·0	5th	DECEMBER, 1895.
Do. Past 8 Years	29·396	29·968	30·133	30th, 1893	28·208	20th, 1893	37°·0	55°·4	6th, 1888	14°·5	22nd, 1890	86°·0	5th, 1891	33—46	2·032	9581	24·0	10th, 1891	Do. Past 8 Years.
THE YEAR 1895 ...	29·337	29·908	30·015	2nd May	28·140	28th March	45°·7	81°·8	24th Sep.	8°·0	6th Feb.	131°·7	21st June	1240—20	24·910	106911	37·0	24th March	THE YEAR 1895.
THE PAST 8 YEARS ...	29·368	29·940	30·133	Dec. 30th, 1893	27·813	Nov. 11th, 1891	46°·9	85°·6	Aug. 18th, 1893	10°·8	Jan. 5th, 1894	138°·0	July 2nd, 1893	1093— 4	24·319	110205	27·5	Feb. 11th, 1894	THE PAST 8 YEARS.

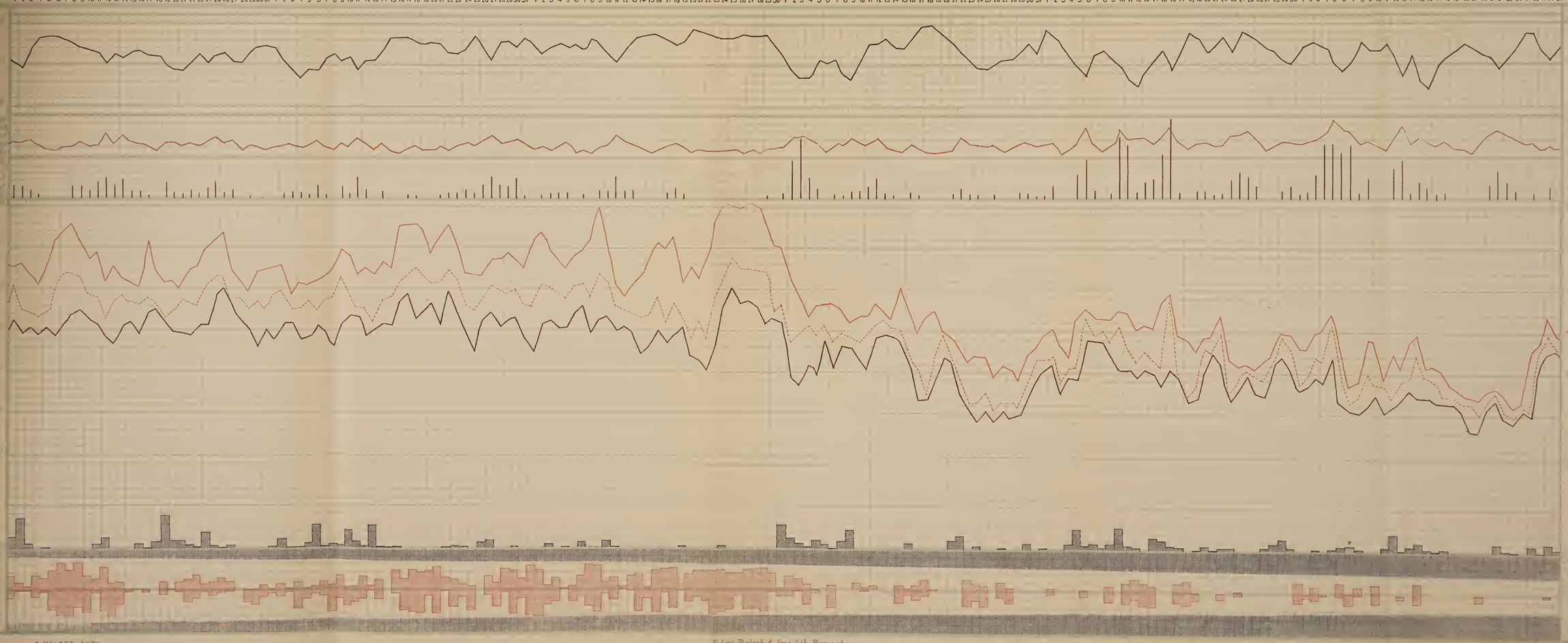
METEOROLOGICAL READINGS EDGBASTON OBSERVATORY FOR JUNE 5

JANUARY FEBRUARY MARCH APRIL MAY JUNE



MELTED SNOW *

Robert Birbeck & Sons, lith. Birmingham.

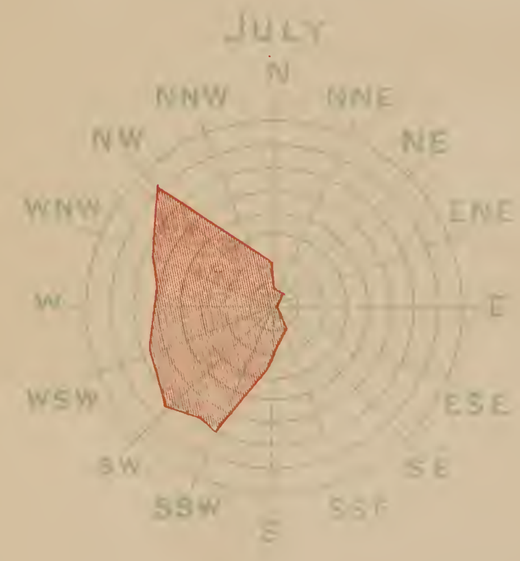


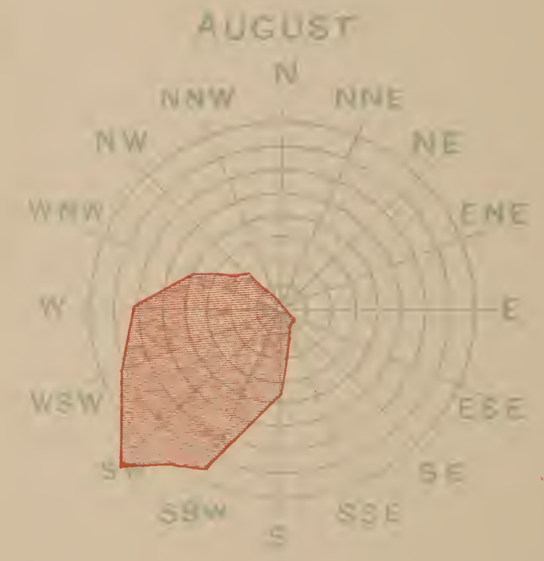
* MELTED SNOW

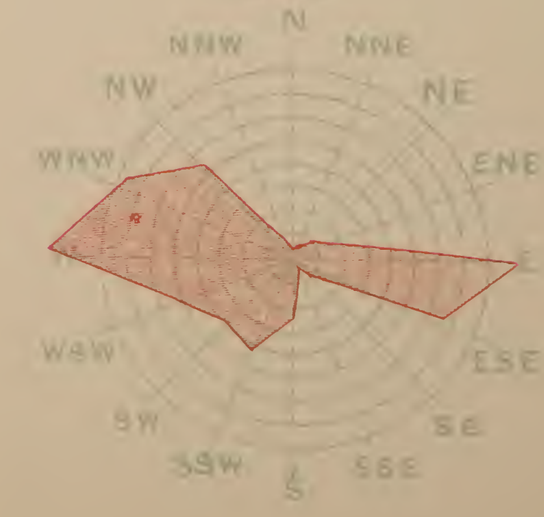
Robert Birbeck & Sons, lith. Birmingham

Meteorological Readings. Edgbaston Observatory.

Horizontal Motion of the Air referred to the points of the Compass for the Year 1895







The Centre being Zero, each Concentric Circle represents 200 Miles

PROCEEDINGS

OF THE

BIRMINGHAM NATURAL HISTORY

AND

PHILOSOPHICAL SOCIETY.

NATURAL HISTORY SOCIETY, FOUNDED 1858.
PHILOSOPHICAL SOCIEYT, FOUNDED 1876.
AMALGAMATED 1894.

"NATURÆ SPECIES RATIOQUE."
Lucretius.

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SESSION 1896 & 1897.

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PROCEEDINGS

OF THE

BIRMINGHAM NATURAL HISTORY

AND

PHILOSOPHICAL SOCIETY.

VOL. X.—PART II.

SESSION 1897.

I.—*The Glacial Boulders East of Cannock Chase.*

By H. G. MANTLE, F.G.S., M.I.MECH.E.

Read before the Society, Wednesday, November 25th, 1896.

[With an Appendix on the Microscopic Characters of the Rocks, By W. BOULTON, A.R.C.S., F.G.S.]

IT was on June 10th, 1893, that I discovered a large rounded Augite Andesite Boulder, five feet in circumference, with adhering hardened till, at the head of a brook course at Hilton, in the parish of Shenstone, near Lichfield, about $7\frac{1}{2}$ miles east of Cannock and Hednesford. I broke off several fragments of the lava and took one to Dr. Lapworth for his opinion thereon. He declared it to be an excellent specimen of a Lake District Boulder identical with the lavas of Falcon Crag on Derwent Water, and he suggested that as no mention, as far as he recollected, had been made of the occurrence of boulders in the neighbourhood, I should give attention to the subject of their local distribution. The late eminent geologist Mr. J. Beete Jukes, F.R.S., F.G.S., in his memoirs of the

Geological Survey of the South Staffordshire Coalfield, published in 1859, refers under the heading of "Drift or Superficial Accumulations" to "Blocks of granite and old trappean rocks evidently belonging to the Great Northern Drift, being found in great abundance all along the western boundary of the coalfield, especially about Bushbury." "They may be found occasionally but by no means abundantly within the limits of the coalfield itself, but on its eastern side they are, as far as my recollection serves me, comparatively very rare." Mr. F. W. Martin, F.G.S., in his first report upon the distribution of boulders in South Shropshire and South Staffordshire, vol. vii, part 1*, says of the South Staffordshire distribution, "On the eastern side of the district I think I may fairly assume that the Cannock Hills have formed an effective barrier against the boulder invasion;" but in his second report, vol. vii, part 1*, he corrects this by admitting that "Boulders lie on the top of these hills at a level of 648 feet, and they are thick upon the ground on the other side of the hills at Hednesford." He does not, however, appear to have gone further east than Hednesford, but to have confined himself to the west of a line drawn from that place through Churchbridge to Cheslyn Hay, cataloguing boulders as occurring at the two latter places, and mapping them as occurring at the first. But in order to be quite sure that the district I am to deal with has not been examined and reported upon, in addition to carefully perusing both Mr. Martin's papers and catalogues, I have closely looked through Mr. Harrison's admirable and useful *Bibliography of Midland Glaciology*, vol. ix, part 2†, but nowhere do I find any reference to the particular places in which I am now able to say that boulders occur. The British Association Erratic Blocks Committee Report in 1873, (*a*) "Great accumulation of boulders at Tettenhall, Bushbury, and Cannock; (*b*) southernmost point for boulders observed is Bromsgrove, most easterly Rugeley." And finally Mr. Martin says, in his second report, "The deposit of English lake and Scotch rocks certainly seems to thin off to the east of a line drawn between Sutton and

* Proceedings of the Birmingham Philosophical Society.

† Proceedings of the Birmingham Natural History and Philosophical Society.

Lichfield." The country therefore to be reported on is new ground, and is comprised within a line drawn from Cheslyn Hay on the west to Hopwas Hays Wood on the east, and from Kings Bromley on the north to Hill Hook near Blake Street Railway Station on the south, the whole representing an area of nearly 150 square miles. Boulders are excessively thick upon the ground between Hednesford and Bloxwich, extending over an area east and south-east of that line of about 6½ miles, beyond which they rapidly thin off, the Birmingham road from Watford Gap to Lichfield appearing to mark the end of the distribution. The boulders are principally derived from the localities of Borrowdale, Buttermere, and Eskdale,* in the English lake district, as well as from Mount Criffel in the south of Scotland. But in regard to the Criffel granite boulders I should like to say that when I was recently in the lake district I was much impressed by the striking resemblance the Skiddaw granite bore to some blocks of granite I had found in our own neighbourhood regarded as Criffel; and since it is generally held that our Andesites, Syenites, and Eskdale granites are derived from this north-western portion of the lake district, I could not see why Skiddaw blocks should not have come down at the same time and account for the common association of granites with the undoubted Andesites and Syenites of that region. The Skiddaw granite is exposed in Syning Gill between Skiddaw and Blencathra, also at the upper end of the Caldew Valley, and again lower down the course of the river. In weathering and general appearance and in mineralogical composition, as far as I could judge by the aid of my pocket lens, it struck me as being so much like our own granites that before leaving the district I sought the acquaintance of Mr. J. Postlethwaite, F.G.S., a local authority, to whom I conveyed my suspicions. He said that the three exposures no doubt formed part of a continuous mass extending over a large area, and that if denudation had made a little

* As will appear from Mr. Boulton's Appendix, the occurrence of undoubted Eskdale Granite is not proved, since the only specimens labelled as Eskdale Granite have turned out, on microscopic examination, to be either Criffel or Skiddaw. However, it is my intention to determine whether or no Eskdale Granites occur in this area.

less progress the Skiddaw granite would still have been buried, and that as so little was exposed, the largest exposure measuring only a mile in length and half a mile in width, he did not think it likely that any of it had gone down to the Midlands with the Borrowdale and Buttermere boulders. However, not being quite satisfied I induced Mr. Postlethwaite to send me on my return a few undoubted typical specimens of the granite taken himself from Syning Gill, and carefully comparing these and one or two specimens I brought back myself, with chips of boulders found in the Hammerwich district, I came to the conclusion that all the granites were identical; but in order to be still more satisfied, I sent well-selected chips of the Skiddaw and local granites to Mr. William Boulton, F.G.S., president of this section*, who has had them prepared in thin sections for microscopical examination, and he kindly informs me, as he will you, that he can see no difference whatever between the one and the other. As to the derivation of the other boulders found, the Rhyolites†, Carboniferous Sandstones, and Millstone Grits, together with certain altered sandstones, are possibly from Shropshire, where somewhat similar rocks may be seen *in situ*, but I think it more likely that they may be derived from the carboniferous rocks surrounding the lake district, while as to rocks of Welsh origin I have seen none, the only ones approaching them being the quartz felsites, and these more closely resemble lake district felsites than they do anything I have seen from Wales. Roughly over the whole area surveyed Andesite lavas and ashes comprise 50 %, Syenite (pink and grey varieties) 25 %, Criffel and Skiddaw granites 12½ %, local Basalts and Dolerites 5 %, and Rhyolites, Rhyolite grits or tuffs, Quartz Felsites, Diorites, Carboniferous and other sandstones and grits and Eskdale granites the remaining 12½%; but the so called Eskdale granites averaged into the boulders found in the particular neighbourhood of their occurrence would make a much more decent show than this, yielding at least 20 %. It is perhaps worthy of note that Norton East is the only district where they occur thickly, but they thinly radiate a mile or two

* The Geological Section of above named Society.

† Rocks thought to be Rhyolites have been determined by Mr. Boulton to be fine Rhyolite tuffs or ashes (see Appendix).

from this nucleus. This rough estimate of the proportions is of course based only on what I actually saw of erratic blocks lying about the surface, but it must be remembered that great numbers have been and are being constantly brought under the stone-breaker's hammer all over the district, and that in a comparatively short time very few of the portable ones will be left as records of former distribution. The Criffel granites, too, may doubtless have formed a larger proportion of the boulders of the district, since owing to the greater ease with which they can be broken up compared with the harder Andesites and Syenites, they may have been used more extensively for road-metalling purposes. A special feature also about the Criffel granites is, that they are invariably smaller than the other boulders, it being exceptional to find one more than eight or nine inches in diameter, while on most heaps of broken and unbroken stones in the Pelsall and Brownhills districts particularly, they may be seen in large numbers from an inch or so in diameter and nearly always rounded. The Andesites vary in texture from coarse porphyritic Andesites with square Felspars and large dark green or black crystals of Augite or Hornblende to fine close-grained greenish Andesites with a glassy texture and conchoidal fracture, breaking with a ring like that of a Skiddaw musical stone, and often showing flow structure. The Syenites are of three types from the Buttermere and Ennerdale district.

1st. The greenish-grey type, with bladed aggregates of dark, apparently black, Hornblende.

2nd. A red type, with little or no Quartz.

3rd. A red type, with much Quartz and Hornblende, making them practically hornblendic granites (Ennerdale).

The so called Eskdale granite is coarse grained and has its felspar impregnated with Hematite, which gives a slightly reddish tint to the rock on a fresh fracture, but which is distinctly more marked on a weathered surface, over which the Hematite radiates like a blot on a piece of blotting paper. The Andesitic Ashes vary from very fine grained to coarse grained rocks with lapilli, while the other rocks, including the Criffel granites, are of the normal type. The

shapes of the boulders are, as to Andesites and Syenites, principally subangular while the Granites and Quartz Felsites are mostly round, but there are exceptions applicable to all the rocks of elliptical or egg-shaped blocks and rectangular blocks with their angles chiefly rounded. Their appearance in weathering varies in all shades of colour from a dark brown to a chalky white, many of the Andesites, particularly those dug up by the Conduit Colliery Co. at Norton, resembling externally huge lumps of chalk. The surfaces of the Andesites and Syenites are often smooth, particularly the Syenites, while the granites are rough, due to the weathering out of the Felspar and Mica, and the leaving of the Quartz crystals standing out in bold relief. The Quartz Felsites, Dolerites, and Basalts are roughish, while the surface of the Rhyolites and harder sandstones is generally smooth, sometimes with superficial pits or indentations. Some of the boulders show striæ, while a few others are covered with adhering hardened till or boulder clay. As to their mode of occurrence Mr. Beete Jukes says, "They are seldom found embedded in any great mass of drift matter, but lie for the most part loosely scattered over the surface of the country." As to that portion of the country lying between Hednesford and Bloxwich, extending for a distance of $6\frac{1}{2}$ miles east and south-east of that line, it may be safely affirmed that boulders are *often* embedded in a great mass of drift material, but east of Hammerwich they are not, but lie, as has been stated, loosely scattered over the surface of the country. At Five Ways, Norton East, and Little Norton, all west of Hammerwich, boulders may be seen cropping out of their grassy surroundings at all angles. In the neighbourhood, as far as Pool Farm, there is an enormous deposit of them of considerable extent and thickness, indicating probably the presence of an ancient terminal moraine. The erratics are of all sizes, from about 2 inches to 15 or 16 feet in circumference, and weighing many of them individually several tons. Many of the arable fields on bright dry days appear to be white over with the smaller ones, and the local farmer may at all times obtain a better crop of stones than turnips. The drift gravel has been proved at various points on the Chase to be of great thickness, to contain large num-

bers of erratics, and to be resting everywhere upon a bed of yellow boulder clay*, estimated roughly at between five and six feet thick. Erratic blocks of cannel coal, glacially striated with adhering light chocolate coloured boulder clay, were taken out of the drift gravel at a depth of eight yards from the surface during the recent sinking of Fair Lady Pit at Five Ways, while a bed of boulders nine feet in thickness was struck in the drift gravel at the sinking of the Cannock and Rugeley Colliery Co.'s Pool Pits at a depth of forty-five yards. Also in sinking the No. 14 Pumping Shaft of the late Pelsall Coal and Iron Company, in 1882, the edge of a bed of boulders between two and three feet thick was struck at a depth of twelve yards embedded in drift material consisting of sand, clay and gravel. They were all crystalline blocks, many of them nearly two cwt. each—spherical, elliptical, angular, and subangular in shape. They are chiefly buried now beneath the sand, gravel, and rock which the pit shaft yielded. A few years ago at Pouk Lane Farm, Hilton, a large, nearly round, superficially rough and much weathered Criffel or Skiddaw granite was struck by a plough, which was ploughing much deeper than usual, at a depth of about eighteen inches, embedded, according to the finder, "in some gravel and clayey stuff." It measures twenty inches in diameter and five feet one inch in circumference, and is at present lying under a hedge in the rickyard at the farm. And still further down, in 1872, there were discovered two smooth crystalline rounded blocks, polished as though by blacklead, embedded in the solid shallow coal at Cannock Wood Pit, the property of the Cannock and Rugeley Colliery Company Limited, without any adhering or surrounding sand, gravel, or clay, or other material whatever, save the actual burnable coal itself. An attempt was made to cut out the cavities in which the boulders lay, but it failed, the coal splintering under the operation. The discovery of these erratic blocks in the heart of the shallow coal of course represents a totally different set of conditions both as to time and manner of deposition to those of the gravels, clays, and boulders of the Glacial Drift period. But I

* This bed of clay is generally regarded as part of the Coal Measure Clay by local Mining Engineers, but Mr. Sopwith agrees with me that it is Boulder Clay.

mention the fact here in order to invite discussion and to draw attention to the more detailed description of the phenomenon in the catalogue. But as to the mode of occurrence of boulders outside this exceptional case, I hope I have at all events proved to your satisfaction that they *are* found embedded in a great mass of drift matter as well as lying loosely scattered on the surface of the country east of the Cannock range of hills. Wall, near Lichfield, the ancient Roman city of Etocetum, is about eight miles east of Cannock, and in a circle including it and Hammerwich boulders commonly occur some of the best preserved specimens in the entire district being found in the latter village. Also in this circle and beyond it, on a line drawn S.E. from Burntwood to Blake Street *via* Hammerwich, Pipe Place, Moat Bank, Hilton, Chesterfield, Lynn, and New Barns are numerous patches of boulder clay, with stones, thickening towards the N.W. and thinning towards the S.E. The colour of the clay is usually brown chocolate, but there is a buff coloured clay of a sandy nature at Burntwood, and in a field at Hilton a white chalky boulder clay with bleached stones. Its thickness varies between three and ten feet, the former being proved at Moat Bank and the latter at New Barns. The brown chocolate clay is usually a strong clay, unstratified and invariably free from sandy or gritty material. With water it kneads well, is sectile and tenacious, and is used for brick-making purposes, but the other clays not being so pure are of little or no economic value. In addition to the boulder clay at Hammerwich may be noted the occurrence of clay ironstone nodules, in some cases with good sigillarioid impressions. One block about five cwt., and measuring seven feet three inches in circumference, has thin plates of burnable coaly material adhering to it, and white carboniferous sandstone filling up the interspaces, while a chip knocked off it revealed a leaf resembling Nueropteris well preserved. I have been unable to find boulders further east than Lichfield, where, during recent excavations for a new gasholder, several were discovered in loose-made ground at a depth of two feet six inches, all of which are of Lake district type, and are described and reported on in the catalogue. I do not affirm there are no boulders

east of this point, but I have not seen any; and some years ago the late Dr. Crosskey said "that he had not seen a trace of an erratic at Alrewas." I have found boulders, description and sizes of which appear in the catalogue, plentifully in Five Ways, Great Wyrley, Norton Canes, Little Norton, Norton East, Pelsall, Chase Terrace, Brownhills, Hammerwich, Pipe Place, Wall, Hilton, Muckley Corner, and Spring Hill; and less numerous at Sandhills, Triangle, Shire Oaks, Moat Bank, Lynn, Chesterfield, Upper Stonnal, Lower Stonnal, Gainsboro' Hill, Burntwood, Edial, Chorley, Balls Mount, Longdon, Armitage, Handsacre, Kings Bromley, Lyncroft, Sandyway, Shenstone, Lichfield, Streethay, Owlet Hall, New Barns, and Farewell.

The levels of these places above the sea at Liverpool vary between 200 and 600 feet, and I agree with Mr. Martin, that where boulders occur, they do so without regard to levels, covering hill and dale alike. As to the catalogue, I should like to say I have endeavoured to make this interesting by adding to the usual enumeration and description of the boulders found, detailed notes of special occurrences and observations on the general state of things in certain local areas. There are special notes headed, for example, "Boulders in the Shallow Coal," "Boulder Clay on Cannock Chase," "Boulders in the Drift Gravel," and "Boulders in Lichfield City." I have also prefixed the catalogue with a full explanation of abbreviations employed in describing the boulders. The Sarcen Stones referred to in the catalogue as lying in the fold-yard at Pipe Place, near Lichfield, are large rectangular blocks of coarse sandstone, 5 to 10 feet long, 3 to 4 feet broad, and 2 to 3 feet thick, and believed by Mr. W. Boulton to be "possibly portions of the waterstones of the Keuper series, which presumably once covered the district." The Halleflintas, of which only three were found, and those at Hammerwich and Pipe Place, may have come from Shropshire or the Lake District. I do not think they are all that have come, and am of opinion that if the ground at Norton East were examined closely several would be found there. I have had four photographs taken of interesting occurrences of drift and boulders, viz.:—A group of six large boulders lying on Brownhills

Common, at the back of the old Wilkin Colliery; two sections of drift gravel between Hammerwich and Triangle; and a group of two erratics, one a rounded Quartz Felsite, and the other the large ironstone nodule before referred to, at a farm near Hammerwich Station. I have brought for your inspection many chips of boulders found, together with a few small whole erratics, from an inch to 5 inches in diameter, as well as a piece of cannel coal taken out of the drift at Five Ways, showing beautiful glacial striæ, as well as specimens of the three varieties of boulder clay occurring in the district. I have used seven six-inch Ordnance Survey Maps, on which I have placed symbols in their proper positions to represent the boulders found; and have transferred the symbols on to a map of my own, drawn to a smaller scale for easier reference, which will be found at the end of this paper. It will be noticed that in this paper I have not attempted to theorise but to state facts, in the collection of which I have been kindly assisted by my friends. The survey of so large a district, together with the measuring and knocking off of chips of the rocks for recognition, has involved the expenditure of a good deal of my leisure time and labour, extending over a considerable period, but the task has been a pleasant and agreeable one. I owe my best thanks and obligations, first to our great and good friend Dr. Lapworth, F.R.S., F.G.S., whose characteristically kind words induced me to take an interest in such a delightful subject; to our respected chairman, Mr. Wm. Boulton, A.R.C.S., F.G.S., who has rendered me valuable assistance in the recognition of doubtful specimens, in the microscopic examination of thin sections, and in the addition of the appendix to this paper; also to Mr. J. Williamson, M.E., General Manager of the Cannock and Rugeley Colliery Company; Mr. Arthur Sopwith, C.E., F.G.S., of the Cannock Chase Collieries; Mr. Charles Fisher, M.E., General Manager of the Coppice Collieries; and Mr. Joseph H. Bullock, M.E., F.G.S., late General Manager of the Pelsall Coal and Iron Company Limited, from all of whom I have received every courtesy and assistance, and who have readily placed at my disposal plans and pit sections for my inspection and use.

CATALOGUE OF BOULDERS.

[*N.B.—All dimensions of Boulders in following Catalogue are expressed in inches.*]

Explanation of Abbreviations.

A. prefixed to Andesite means Augite Andesite.
H. ditto Andesite means Hornblende Andesite.
B. ditto Syenite means Buttermere.
B. ditto Andesites means Borrowdale.
C. ditto Granites means Criffel.
C. ditto Sandstones means Carboniferous Sandstones.
B. ditto Clay means Boulder Clay.
E. ditto Granite means Eskdale Granite.
E. ditto Syenite Ennerdale.
E. L. affixed to Rocks means English Lakes.
Q. prefixed to Felsites means Quartz Felsites.
Cir. means Circumference of a Boulder.
Dia. means Diameter.
Sub. means Subangular in shape.

The figures in brackets refer to the heights above sea level at which Boulders are found.

Hammerwich Village (Level 467).

About Mr. Richard Ashmall's farm premises.

B. Syenite—43 by 31 by 94 cir., much rounded surface, smoothish.
ditto 17 by 12, sub., smoothish surface.
Augite Andesite—26 by 65, sub., corners rounded.
B. Syenite—32 by 33 by 77 cir., surfaces rough, sub.
ditto 20 by 24 ditto.
Andesite—31 by 32 by 89, flattened on upper surface.
ditto 45 by 34 by 99 cir., sub.
B. Syenite—36 by 27 by 84 cir., roundish, surface smooth.
Andesite—24 by 16, angular, weathered whiteish.
Eight smaller Andesites and Syenites.
Audesite Ash—40 by 44 by 114, very course grained and rough surface.
ditto 36 by 34, squarish rounded edges.

Note.—There are many other smaller ones here in the stable floorings and around the foldyards and buildings. Those enumerated above are the largest and best preserved Boulders in the Hammerwich district, being sounder and not so badly weathered as others.

Mr. Edward Eglington's, Fair View House (Level 467).

In field by gate opposite.

Augite Andesite—24 by 18, rounded, surface rough.

Mrs. Osborne's, Overton Farm.

Headstone to brook by foldyard gate.

B. Syenite—23 by 18 sub., surface smoothish.

In foldyard and buildings.

A. Andesite—14 dia., sub.
Q. Felsite—24 dia., rounded, chip broken off.
B. Andesite—16, rounded.
ditto 14, sub.
ditto 18, sub.
Several Syenites, all English Lakes.
Grey Syenites (3)—about 9 dia.
Basalt—7 and 9 respectively, angular.
Granites (4)—about 8 dia.
Q. Felsite—11 dia., round.

There are hundreds of erratics in and about these premises ; the foundations of some of the farm buildings are made of them, whilst the floors of the stables and the yard around the foldyard are principally composed of them.

In Duck Pond, near Mr. Fearn's Farm (Level 460).

B. Syenite—9 by 6, flat on one side, corners rounded.
ditto 12 by 9, sub., smooth.
ditto 9 by 8, sub., smooth.
B. Andesite—16 by 11, sub., roughish surface.
A. Andesite—about 12 dia., rounded.
I did not examine Mr. Fearn's farm premises.

Mr. Hall's Farm (Level 415), Hammerwich towards Burntwood.

C. Granite—dug up in making a drain across road, 12 by 9.
E. Granite (probably)—14 by 8.
Amygdaloidal Basalt—round, 5 dia., smoothish surface.
Quartzite—large, 18 by 12, unlike local quartzites, with deep cut about $\frac{1}{8}$ deep, and several pot holes and scratches. The surface with the holes cut and scratches is flat, corners all rounded.
Syenites (E.L.)—several small ones about, but no Andesites.

Note.—There is a small duck pond in a field on the farm, showing an exposure of drift material, angular and subangular and rounded stones, white sand and clay.

Mr. Peace's Farm, near Hammerwich Station (Level 400).

B. Syenite—12 dia., flat on one side.
Rhyolite—12 dia., sub., flattened surface.

A. Andesite—12 by 7, sub.
Millstone Grit—8 by 5, sub.
Torridon Sandstone—about 9 dia., sub.
Syenites and Andesites, several others, small.
Argillaceous Ironstone Nodule. See Note and Photograph.

Note.—In Mr. Peace's front garden there is a massive Argillaceous Ironstone Nodule, weighing about 6 cwt., with coaly material adhering to it, and carboniferous sandstone (white) filling up several of the interspaces. Has weathered dark brown and yellow. A portion of the upper surface has been broken off and exposes thin plates of calcareous cementing material. A chip knocked off the concretion displayed a fossil leaf resembling neuropteris, well preserved. The shape is somewhat conical, and is capped by concentric depositions of the ironstone. The base shows striæ to the central axis, whilst the concentric cappings are horizontally bedded. Height 2ft. 6in., round base 5ft. 8in., round top 4ft. 6in., circumference 7ft. 3in. In addition to this I have found several small blocks of clay ironstone in the neighbourhood, some nodular in shape, others angular, but mostly flattish, with surfaces showing good sigillarioid impressions and adhering coaly material. Size from 2 to 8 inches along their principal axes.

Hammerwich Lane.

Two small Criffel or Skiddaw Granites about 8 in. dia.

Mr. Wilkinson's Garden near Hammerwich Railway Station.

Q. Felsite—14 by 12, sub.
Grey Syenite—13 dia., rounded.
A. Andesite—15 by 9, sub.
And several smaller erratics.

Corner of Cross Roads near Hammerwich Station (Level about 400).

Q. Felsite—15 by 14 by 39 cir., rounded. Photographed.
Hallêflinta—14 by 13, flattened and smoothed surfaces.
Limestone Fossiliferous—20 by 10, angular, resembling Wenlock.
C. Sandstone—14 by 10 by 33, sub.

Hammerwich Hall Farm (Level 400).

A. Andesite—14 by 12, sub., rough surface.
ditto 16 by 15, ditto.
ditto 16 by 12, ditto.
Andesitic Ash—11 by 9, sub., rough surface.
B. Syenite—about 14 dia., rounded.
ditto 13 dia., rounded.
And many others built into floors of stables and forming coping around the premises.

Gordon's Meadows.

Near gate post in field.

B. Syenite, large—36 by 28 by 108 cir., flattened on upper surface, edges rounded, running into an angular neck at one end, surface smooth.

Pipe Place near Lichfield, Mr. H. Bradburne (Level 365).

Diorite—12 by 10, flattish both sides, corners rounded.
ditto 20 by 15, triangular.
Cambrian Quartzite—20 by 14, triangular, smooth, edges rounded.
ditto 14 by 20, edges round, surface flat.
Sarsen Stone—69 by 36, rectangular block, probably from the Keuper formation.

Note.—Several other large rectangular blocks in foldyard, partly buried beneath the causeway, edges of which may be seen, and measuring, according to a local authority, 8 to 9 feet long.

Andesite—10 by 9, coarse surface, egg shaped.
ditto 18 by 10 by 33 cir., hummocky looking, angles rounded, surface amygdaloidal.
Syenite—12 by 8 by 28 cir., sub., rounded edges.
ditto 19 by 12 by 46 cir., rounded.
ditto 15 by 10 by 40 cir., ditto.
ditto 17 by 9 by 37 cir., ditto.
ditto 11 by 6 by 33 cir., squarish, flat surface, sub. edges.
Cambrian Quartzite—13 by 10 by 38, triangular, rounded edges.
Criffel Granite—16 dia., rounded, uneven surface.
ditto 12 by 10 by 24 cir., rounded, uneven surface.
Hallêflinta—Large sub. block.

Note.—There are scores of erratics beside these built into the causeway of the foldyard, as well as constituting all or part of the floors of stables, principally Andesites and Syenites, with a few C. Granites and many Basalts, the latter probably having been purchased for the purpose.

Boulder Clay—There is here also a considerable deposit of brown chocolate Boulder Clay occurring bisecting the Pipe Hill Road, near the railway bridge, and intersecting three fields in a S.W. direction, and believed to be from 3 to 6 feet through it, on to the sandstone rock. The exact line of the clay may be delineated in the fields by the appearance of growing crops, which ripen later on the clay than those in the same fields on the light sandstone soil. The residence and outbuildings on the Pipe Place estate was built of bricks made from this clay, and Mr. A. Bradburne says the large boulders around the buildings are believed to have been dug up during the excavations.

Hilton (Level 390).

At head of brook course near Mr. H. G. Mantle's turf field gate.

A. Andesite—22 by 21, about 65 cir., rounded, surface rough.

At head of small bridge over Cranebrook, Mr. Brown's meadows.

A. Andesite—18 by 12, sub., with adhering small stones.
Andesite Ash—12 by 11, sub., in bank near brook.

Note.—A newly-made drain in these meadows revealed a small exposure of chalky boulder clay, with small bleached angular and rounded stones.

Cranebrook, Mr. Bagshaw's.

Andesite Ash, with Lapilli—14 by 11, rough surface, rounded.
ditto about 9 dia., rounded.
ditto several small ones on premises.
Basalts—several small squarish blocks about 6 dia., in stable flooring, some showing pyrites.
Dolerite—9 dia., squarish.

Note.—These Basalts may have been sent from Rowley for paving purposes, although there are not more than 2 to 3 cwts. altogether

At sheepwash, 200 yards from Bagshaw's towards Chesterfield.

A. Andesite—24 dia., rounded with conspicuous squat crystals of augite.
Dolerite—16 dia., rounded, in bank near.

Mr. Hodgkins, wheelwright's house, corner of Pouk Lane.

Syenite, 9 by 8, sub., smooth.
Andesite—12 by 6, oblong.
Ditto 14 by 11, sub.
Syenite—8 by 8, round, roughish surface.
Felsite—10 by 8, sub.
A. Ash—about 9 dia., rounded.
And several others.

Muckley Corner (Level 415).

Mr. Robinson's farm, Watling Street.

C. Sandstone—24 by 12, flattish, sub.
Cambrian Quartzite—19 by 12, sub.
ditto 18 by 11, sub.
ditto 19 by 13, sub.
ditto 10 dia., rounded.
Andesite—14 by 10, rounded.

In roadside bank near.

Andesite—12 by 10 by 9, sub.
ditto 14 by 16 by 11, sub.

Mr. H. G. Mantle's, Melrose House (Level 419).

C. Granite—7 by 4 by 18 cir., rough surface.
B. Syenite—9 dia., rounded, surface smooth.
Gray ditto—about 12 dia., rounded, surface smooth.
Basalt—9 by 8, squarish, angles rounded.
Ditto 10 by 7, ditto ditto
Ironstone, Sigillarioid, with adhering coaly material, flattish, 8 dia.
Clay Ironstone—several small pieces, from 2 to 3 dia.

Near Boat Inn, Summerhill.

Here the drift gravel, 9ft. in thickness, may be seen resting on an occurrence

of fine red sand without stones of the Bunter formation. Erratics have been taken out of the gravel.

Opposite Boat Inn (Level 411).

Syenite—In road bank, oblong, about 12 by 7.
Andesite— ditto sub., 8 dia.
ditto 9 dia., in drift gravel exposure in Follow's field.

Mr. Jackson's, Pouk Lane Farm, near Hilton (Level 394).

Skiddaw Granite—20 by 20 by 61 cir., rounded, rough surface, ploughed up in field near farm buildings, at depth of 12 inches.
Andesite Ash (coarse—20 by 18 by 58 cir, sub.
Syenite—20 by 17 by 48 cir., sub.
C. Sandstone—16 by 12, rounded.

On roadside heap of stones near.

C. Granites—4 small ones, rounded, 10 to 12 dia., surface rough.
Andesite, 9 by 8, sub.

At head of local well in lane nearer Hilton.

Andesite Ash—16 by 9, flattish, corners all rounded.
ditto 15 by 12, sub.
Andesite—16 by 14, sub.

Mr. H. G. Mantle's, Ivy House Farm, in Foldyard (Level 394).

Syenite—Sub., smooth, about 6 dia.
ditto Sub., smooth, 7 dia.
Andesite—Oblong, about 18 long, roughish.
Sandstone resembling Torridon.
C. Granite—9 dia., rough.
C. Sandstone—small, roughish.
Permian Breccia, and several smaller erratics.

Mrs. Beetlestone's Spring Hill Farm (Level 440).

Andesite—At entrance gate, 30 dia., flattish, corners rounded.
A. Andesite ditto 36 dia., ditto ditto.
ditto Field gate, 16 by 13, sub., striated.
Andesite Ash—26 by 14, sub., striated.
Carboniferous and local sandstones.

Mr. H. G. Mantle's, Cranebrook Farm.

Dolerite—14 by 12 by 34 cir., angular, surface smoothish.
ditto 7 by 7 by 20 cir., ditto ditto
Andesite Ash—9 by 8, weathered white, surface rough.
C. Sandstone—10 by 7, sub., rough.

Stonehouse Farm.

No Boulders. Quartzites and local Bunter Sandstones.

Mr. Roberts' Warren House Farm, Ogley Hay (Level 400).

B. Syenite—Entrance gate to foldyard, 36 by 24, sub., surface very smooth.

On roadside heap near cross roads.

C. Granite—9 by 7, rounded.
ditto 8 by 6, rounded, much weathered quartz crystals prominent.
ditto 10 by 8, rounded.

Note.—I did not go into the foldyard at this farm, but have no doubt there are many erratics in and around the buildings.

In hedge bank towards Brownhills.

Andesite—12 by 9, oblong.
ditto 10 by 8, oblong.
Andesite Ash—About 9 dia., rounded.
Syenite (Red)—About 8 dia., rounded.

Chesterfield (Level 329).

Mr. William Lakins, Ashcroft Farm.

Dolerite—18 by 12 dia., sub., smooth surface, edges rounded.
C. Sandstone—9 by 8, rounded.
Millstone Grit—About 6 dia., rounded.
Andesite—9 dia., sub., in hedge bank.

Mr. Cheatle's Farm.

Andesite Ash—24 by 18 by 62 cir., sub., in rickyard by gate.
C. Sandstone—14 dia., round, very hard, close grained.

At corner of lane.

C. Sandstone—20 by 16, squarish.
ditto 14 dia., round, in bank.
Andesite—12 by 14, rounded.
ditto 10 by 9, sub.

Further along in bank in lane, Lynn to Chesterfield.

Andesite—12 by 9, sub.
ditto 13 by 7, oblong.
Syenite (E. L.)—9 dia., rounded.
ditto 6 dia., rounded.

Wall (Level 369).

In road near Captain Harrison's Manor House Farm.

Andesite—14 by 12, round, rough surface.

In Foldyard of Manor House Farm.

Andesite—Close grained, 42 long by 24 by 104 cir., rectangular block, edges all but one rounded, probably a fine Ash.
Andesite—32 dia., 101 cir., sub., surface uneven.

In lane near Farm.

Andesite—12 by 8, rounded.

Near Trooper Inn.

C. Sandstone—Close grained, 14 by 12, rounded.

Mr. Arthur Bradburne's Wall Lane Farm Foldyard.

Andesite (Augite)—24 by 22 by 64 cir., sub., weathered smooth.
Millstone Grit—17 by 10, rectangular block.

Moat Bank, Mr. A. Bradburne's.

Quartzite—21 by 14 by 53 cir., rounded, hard and smooth surface.
ditto 10 dia., rounded and fossiliferous.
Andesite—11 by 9 by 36 cir., rectangular, surfaces flat, corners rounded.
Clay—Occurrence here of brown chocolate Boulder Clay, 3 feet thick, thinning off in a S.W. direction.

Burntwood (Level about 400).

In Church Bank, towards Green.

Andesite—12 by 10, rounded, large porphyritic crystals of white felspar.
ditto 14 by 11, close grained, in lane near church.
ditto 13 by 9, sub.
Several Andesites and Syenites near schools on the way towards Ball's Mount.
Boulder Clays.—Buff-coloured Clay of a sandy feel in field near church. Brown chocolate Clay of good sectile quality in churchyard and field adjoining, occurring less than 2ft. from the surface, thinning off towards the north and thickening towards the south. The stones occurring in the clays are superficially smooth, rounded, angular and subangular in shape.

Triangle.

Andesite—14 by 9, sub., angles rounded off.
ditto 12 by 9, ditto ditto
ditto 18 by 16, ditto ditto
B. Syenite—About 13 dia., rounded.
ditto ditto 10 dia., oblong.
Q. Felsite—9 dia., rounded.

Edial (Level 400).

Mr. George Wilson's farm.

Andesite—16 by 12 by 41, flattened one side, corners rounded.
ditto 12 by 11, rounded, surface rough.
ditto 14 by 9 ditto ditto.

Mr. Hulme's cottage, in field.

Rhyolite—12 by 10 by 24 cir., flattened, smooth indented surface.
Andesite—9 by 8, rounded, rough surface.

Mr. Hulme's farmhouse, near pool.

Andesite—9 by 5, egg shaped.

Andesite—8 by 5, rounded.
ditto 11 by 5, oval shaped.
ditto 12 by 9 ditto
Clay—Brown chocolate Boulder Clay.

Pipe Hill and about Common.

Andesite—12 by 9, sub.
ditto 11 by 10, sub.
ditto About 14 dia., angular.
Syenite—13 dia., in bank, rounded.
C. Sandstone—14 dia., sub.
Millstone Grits—Several about.

Boulders in Lichfield City (Level 255).

During the early part of this year the Lichfield City Gas Company made excavations for a large new gas holder, 84 feet in diameter and 20 feet deep. They passed first through 4 or 5 feet of loose made ground, consisting of ordinary refuse, gravel, sand, and stones, resting on a natural occurrence of somewhat hardened greenish mud 3 ft. thick, containing bleached quartzites, leaves, and rushes of the bullrush type, as well as fresh water shells of the genus Unio. There were standing erect in the mud a number of stout wooden stakes, measuring 18 inches to 2 feet in length, sharpened at the drift ends, and arranged in a row pointing in a north-easterly direction. They were for the most part in a good state of preservation. This stratum of mud, indicating the former existence of a lake or pool, lay on an interesting deposit of peat 4 feet 6 inches to 5 feet in thickness, containing large roots, stems, and branches of trees in association with skulls, teeth, bones, and tusks of animals, the denizens of an ancient forest. The peat deposit rested on a bed of Bunter conglomerate varying between 18 inches and 2 feet 6 inches, beneath which occurs a hard, close-grained, mottled sandstone bed, also of the Bunter series, and constituting the foundation of the gas holder.

Among the erratics found in the superficial deposits were the following:—
Andesitic Ash, with lapilli—13 by 12 by 34 cir., rounded, and surface roughish.
B. Syenite, 8 by 4 by 18 cir., angular.
Andesite Ash—8 by 4, angular.
Grey Syenite—12 by 7, sub.
Dolerite—8 by 6, sub.
Carboniferous Sandstone—5 by 4, rounded.
C. Quartzite—4 by 3, sub.
B. Syenite—6 by 5, rounded.
Also Millstone Grits, including one large angular block and many coarse red sandstones and grits.

Sandy-Way, Lichfield.

In retaining wall adjoining Royal Oak Inn, Sandy-Way.

Andesite Ash, 11 by 6, sub., weathered white, brown crust.

B. Syenite—12, along exposed face, oblong block.
ditto 7 by 5, angular.
ditto 7 dia., sub.
Dolerite—10 long, one face rounded.
ditto 6 by 4, sub., in road near.

On heap of stones near Poolfields Farm, Leomansly.

C. Sandstone—12 by 4, smooth surface, rounded angles, elliptical in shape.
Andesite—6 by 4, smooth surface, sub.
Also several small A. Ashes, 4 to 5 in dia., sub., surfaces more or less white.

Lyncroft (Level 350).

On side of road, near gate facing Colonel Webb's house.

Andesite Ash, 21 by 22, oval shaped, smoothish surface, brown crust.

At Riley Hill and on road half a mile south of King's Bromley are—

Two large rectangular blocks of coarse red Sandstone.
One 36 by 28 } probably local.
One 51 by 18 }

King's Bromley (Level 200).

Note.—No large Boulders in village or immediately around it, but heaps of stones taken from the fields, and particularly from fields in the neighbourhood of the common, contain many erratics of small size, varying from 2 to 6 inches along their principal axes. There is a large variety, among which are Andesites (lavas and ashes), Syenites of the Buttermere light salmon coloured type, carboniferous Sandstones, and Grits in great numbers, and light and dark coloured Flints with Fossils, several of the latter being of considerable size. I was accompanied by Mr. T. C. Averill in my inspection of this district, and he admitted the occurrence of flints and other erratics in the fields. Among them are the following:—

In Mr. Bannister's front garden.

Dark-coloured Flint—7½ by 5, with fossils, angular, conchoidal fracture.
Light-coloured Flint—8½ by 8 ditto ditto ditto

On heap of roadside stones in turnpike road near vicarage.

Andesite—3 by 2, sub., weathered white, brown crust.
ditto 2½ by 1½, sub., ditto ditto
Syenite—2 by 1¾ by 6½, rounded, smoothish surface.
ditto 2 by 1½ by 6, sub., smoothish surface.
And several others.

On heap of roadside unbroken stones, opposite Mr. T. C. Averill's house on the Lichfield Road.

Andesite—6 by 4 by 13½ cir., somewhat elliptical, roughish surface, weathered white.
Amygdaloidal Andesite—3½ by 2¼ by 10½ cir., elliptical, whitish surface.

Syenite—3 by 1½, sub., small superficial pits.
Andesitic Ash—2½ by 1, sub., weathered white, roughish.
ditto 2½ by 1½, sub., ditto
Jasper—Several small pieces.
Flints—Ditto ditto
C. Sandstones and Grits of all textures.

Heap of stones under long wall at Mrs. Bagot-Lane's.

Collection similar to above.

In yard at Royal Oak Inn.

Andesite—3 by 2 by 8½ cir., oval shaped, whitish surface, brown crust.
Large number of blocks of Sandstone in garden here, all local.

Handsacre (Level 261).

In field at farm, near Crown Inn, on heap of unbroken stones.

Andesite—9 by 6, sub., weathered white, rough surface.
ditto 8 by 4, sub. ditto ditto
A. Ash—10 by 6, sub. ditto ditto
ditto—5 by 4, sub. ditto ditto
Many C. Sandstones and Grits.

Armitage.

In lane going up a hill from village, at corner of garden bank.

Rectangular uneven block of black Flint—16 by 11.
Also several large, close-grained, hard, white Rocks, like Cambrian Quartzite.

Longdon.

Opposite Swan-with-Two-Necks Inn in the Village of Brook End, in the Parish of Longdon.

C. Granite—26 by 21 by 14 and 69 in cir., rough surface, pear shaped, angles all rounded. Found in garden at back of blacksmith's shop five years ago by Mr. Joseph Smith. Has a cut about ⅛ in. deep and $\frac{3}{16}$ in. wide across its shortest axis.

C. Granite—Forming hearth of blacksmith's shop fire place, rectangular block, 28 by 15, upper surface smoothed by constant use, angles rounded.

Note.—I made careful enquiries about these large blocks, but all I could learn was that one was found, as above stated, in the blacksmith's garden, and the other no light whatever could be thrown upon it. The blacksmith had never seen the colour of his hearthstone until I got him to break me off a specimen, and he then expressed astonishment at its beauty. Both the Boulders are well preserved, and the chips I obtained are excellent ones.

Lynn (Level 386).

Duck Pond near Lynn Hall.

White Quartz—16 dia., rounded, resembling Cambrian Quartzite.
Andesite—17 dia., sub.

Dark Red Sandstone—Close grained, 12 dia., rounded, resembling Torridonian.

Lynn House (Level 373), Mrs. Beard's gateway entrance.

B. Syenite—22 by 20 by 59 cir., smooth surface, rounded.

In Hedge Bank, opposite Lynn House.

A. Andesite—14 by 14 by 54, squarish, one face sharp, others rounded.

At Bailiff's house.

A. Andesite—Rounded, 18 by 10, smooth surface.

In a garden near Lynn Hall.

Two Andesites—about 12 by 10, sub.
Two B. Syenites—14 by 12, sub.

On roadside heap of stones.

Two small angular blocks of Syenite—6 by 5 and 7 by 4.
One Rhyolite—5 by 4, uneven surface, rounded.

NOTE.—Boulder Clay. At 5 feet beneath drift gravel occurs a bed of strong brown chocolate Boulder Clay, commencing at Lynn Hall and extending through the garden in a S.W. direction to New Barns, where it can be seen cropping out. A new drain exposure in a field at New Barns shews the clay with angular and rounded stones; it ends in a lane near the house. The clay has been proved on the farm to be 3 feet thick, and of good quality.

NEW BARNS FARM (Level 360).

B Syenite—18 by 12 by 46 cir., rounded and smooth.
C. Sandstone—12 by 11, rounded.
Boulder Clay, deposit of.

NOTE.—There is a Peat deposit here, beneath which is a layer of Gravel, then a layer of white Sand, excessively fine.

OWLET HALL (Level 349).

On roadside heap of broken stones near.

C. Granite—9 dia., round, prominent quartz crystals.
Syenite—14 by 6, angular, probably detached from large block.
Rhyolite Grit—14 by 9, flattish surfaces, uneven and indented.

SHENSTONE COURT, R. P. COOPER, ESQ.

No trace of Boulders around house or in fields near, but strong Boulder Clay occurs in the neighbourhood, several feet in thickness and of good quality.

At Mill.

NOTE.—Several large and small scoriaceous Cinders, derived probably from smelting furnaces said to have formerly existed in the neighbourhood. One large heavy one in bank nearer Little Aston, rich in iron, and perhaps 2 cwt.

Near Watford Gap, on roadside heap of partly broken stones.

A. Andesite—12 by 10
ditto 9 by 7
ditto 14 by 9
ditto 9 by 6
} Corners all rounded, and surfaces roughish and whitish.

C. Granite Nodule—6 dia., rough surface.

At cottage, Watford Gap.

Large Millstone Grit—20 by 14, corners rounded.

Note.—Several of these occur scattered about the neighbourhood, probably previously used at the local mill at Mill Green for grinding purposes.

Mr. Robert Lea's, Hillhook Farm.

Clay of the usual colour, with stones.
Ditto at Clayrough, near.

Old Tollgate House, London Road, near Weeford.

No Boulders.

Duck Pond, Watling Street Road, Weeford.

One large Sarsen Stone—16 by 16, flat, angular, weathered whitish.

Plantation Farm, near Sandhills.

Note.—About 23 years ago Mr. Thomas Seedhouse, the then tenant of the farm, in digging a trench for the plantation of a hedge, discovered eight to ten large boulders, some requiring three men to remove them, at a depth of from 2ft. 10in. to 3ft. 3in., embedded in gravel mixed with clay. The present owner has taken the hedge out again, and restored the field to its original size. From the description given to me of the blocks by one who helped to remove them, I should say they were probably Lake District Andesites and Syenites.

Shire Oaks Hill (Level 576).

Level at Shire Oak Inn, 567 B.M.

Andesites, 3
Syenites, 2
C. Granite, 1
C. Sandstone, 1
Q. Felsite, 1
} All occurring partly buried in roadside on the Lichfield side forming coping, all largish blocks, rounded or oval shaped.

Shire Oaks Hill to Rushall (Level 576).

On both sides of the road from Shire Oaks Hill S.W. along the Walsall Road towards Rushall village Boulders occur at short intervals, conspicuous among which are occurrences opposite Mr. Batkin's grocer's shop on entering Walsall Wood, at Jolly Collier Inn, Walsall Wood, in road also, in hedge bank near, near Cottage Spring Inn, Shelfield, in lane near, at Mr. Brawn's farm at Shelfield, at entrance gate, in meadows and at head of a brook course in meadows, as well as in a retaining wall in Rushall village. Most of the Boulders are of the English Lake District type, with here and there a few

local Basalts, and in most cases, particularly the Andesites by Mr. Batkins, of large size, rounded and subangular in shape. Mr. Duignan has informed me of the occurrence of a large Erratic at Fulbrook, near Walsall, which, however, I have not had the opportunity of examining. He regards it as a metamorphic rock.

Shire Oaks Hill, to Castle Hill and Upper Stonnall (Level 436).

Andesite—24 by 12, sub.
ditto 16 by 13, sub.
ditto 18 by 11, sub.
Dolerite—16 dia., rounded.
Basalt—angular.
Quartzose Sandstone—large rounded block.
Syenite—14 by 12, sub.
ditto 9 dia., rounded and smooth surface.
And several others in immediate neighbourhood.

Manor House Farm, Mr. Wright's.

Several small Boulders around and opposite the house of the Andesite and Syenite type. Lake District Boulders also occur on both sides of the road from Shire Oaks to Mill Green at short intervals.

Lower Stonnall (Level 400).

Corner of lane at Lower Stonnall.

A. Andesite—14 by 11, sub.
ditto 16 by 14, sub.
ditto 19 by 10, sub.
Scoriaceous lump—24 by 23, squarish, probably local cinder.

Note.—There are several cinder-like looking lumps in hedge banks and around foldyards in this neighbourhood, derived probably from former local ironworks. Brown chocolate Boulder Clay and Gravel occurs here.

Mr. John Brown's Laurels Farm, Lower Stonnall.

Agglomerate—16 to 14, sub., flattish (called cough mixture).
Andesite—near stables in lane, 16 dia., oblong.
ditto 18 dia., oblong.
ditto 24 dia., oblong.
ditto 14 by 20, near cottage.

Mr. Thomas Craddock's Swan Farm, Lower Stonnall.

Andesite Ash—18 by 16, sub.
Andesite—16 dia., nearly square, but edges rounded.

Note.—Several small Andesites in entrance to foldyard; also several small Andesites, Syenites, and Felsites on heap of roadside stones.

Towards Gainsborough Hill (Level 400).

Chester Road Cross Roads.

Andesite—12 by 10, sub., rough surface.
ditto 9 by 18, sub., smoother.

Gainsborough Hill, in roadside.

Andesite—19 by 15 by 14, squarish, angles rounded.
ditto 18 by 10, angles rounded.
Limestone—16 by 14, angular.
ditto 10 by 8, angular.

Note.—Several blocks of fossiliferous Wenlock Limestone about here, derived probably from Daw End or Walsall.

Mrs. Mary Savage's Frenchcroft Farm, Mill Green, near inn.

A. Andesite—24 by 16, sub.
ditto 27 by 16, sub.
Vesicular Basalt—18 by 14, rounded and smooth surface.

Mr. Corngrave's Mill Pool Farm, Mill Green.

Millstone Grit—24 by 14, angular.
Q. Felsite—12 by 10, angular.
H. Andesite—16 by 11, flattish, corners rounded.
Q. Felsite—14 by 10, sub.
Whittington Village and Heath—No Boulders.
Rock Hill, Hints—No Boulders.
Hints Village—No Boulders.
Towards Fazeley and Wilnecote, S.E. from Hints.—No Boulders.

Note.—On the south-east of the Birmingham Road from Lichfield towards Shenstone Wood End there is no trace of even a doubtful Boulder, and since they are fairly plentiful in the region north-west of this line, running close up to it at Wall and Chesterfield, the Birmingham Road may be taken as practically marking the end of the distribution.

Towards Hints.

Several Scoriaceous Blocks, some rich in iron of local derivation. In 1771 a pig of Lead was found on Hints Common weighing 180lbs., and bearing an inscription, "Imp. vesp. vii t.v, Coss."

Pelsall Pumping Shaft.

In sinking the present Pumping Pit Shaft at the Pelsall Colliery of the late Pelsall Coal and Iron Company in 1882, known as No. 14 Shaft, the feather edge of a bed of Boulders, between 2 feet 6 inches and 3 feet thick, was struck at a depth of 12 yards embedded in a matrix of drift sand and gravel, yielding a large quantity of water. They were all crystalline blocks, weighing from ½ewt. to 2cwt. each, spherical, angular, subangular, and elliptical in shape. Two other shafts were sunk at distances respectively of 130 and 200 yards

from the Pumping Shaft, yielding no Boulders. Most of the Erratics are buried beneath the earth and rock which the pit shaft yielded.

PELSALL AND PELSALL COMMON (Level 480).

On Common, near New Inn.

Andesite—24 by 16, sub., surface smooth.
ditto 16 by 12, sub., ditto
Syenite—16 by 15, sub., ditto
Granite—About 36, round, rough.
Felsite—About 12 dia.
Dolerite—About 15 dia., sub.
And several large ones about Common.

In the principal street leading towards Brownhills, past the Queen's Hotel.
Several Syenites, Andesites, and Ashes.

Corner of Town Lane, in bank.

Andesite—About 16 dia., sub., smoothish.
ditto About 14 dia., smoothish.
Altered Granite—About 20 dia., rounded, roughish surface.

At back of Pumping Plant of the Pelsall Coal and Iron Co.

Q. Felsite—About 19 dia., sub.
Andesites (2)—About 18 dia., oblong in shape.
Andesite Ash (L.D.)—13 by 6, sub.
ditto 16 by 10, sub.
ditto 14 by 6, sub.

At this point several Erratics may be seen protruding through the ground, while a great number are believed to be buried beneath an ash-mound at the back of the enginehouse. All English Lake Boulders that I saw.

Opposite Colliery Offices, near Canal Bridge.

Large Andesite—34 by 20, oblong in shape, edges rounded, surface smooth, and weathering white, with brown crust. English Lake District.

Near Ironworks, Old General Offices.

Metamorphosed Granite, 30 by 23 by 37, somewhat egg-shaped, rough honeycombed surface, probably from Mount Criffel, South Scotland.

The cottage of Benjamin Barton, on the road between Pelsall and Brownhills, and almost opposite Pelsall Farm.

Here is a perfect exhibition of Erratic Blocks of all shapes, varieties, and sizes, from an inch or two in diameter to 3 and 4 feet. An isolated barn wall is composed almost entirely of them, whilst the cottage, piggeries and other outbuildings have them for their foundations. Altogether the assemblage is a very remarkable one, and incomparable in point of number and variety with anything I have seen elsewhere in the district. They are principally Boulders from the English Lake district, the Andesites being of the Falcon Crag type from near Keswick, whilst the Syenites are from Buttermere. The Granites

are probably from Mount Criffel, but some resemble the Syning Gill Granite of the Skiddaw range. Others of the blocks have travelled no further than from Shropshire. Here are a few of them :—

A. Andesite—14 by 6, sub., smoothish surface.
ditto 10 by 6, sub., ditto
Granite (altered)—11 by 7, sub., ditto
Buttermere Syenite—11 by 10, rounded, rough surface.
Granite (like Syning Gill)—12 by 9, rounded, rough surface.
Andesite Ash—24 by 22, sub.
Q. Felsite—16 by 13, rounded.
B. Grey Syenite—18 by 12, sub.
C. Granite—24 by 16, rounded.
Q. Felsite—16 by 14.
Rhyolite Grits (3)—About 9 to 11 dia.
Hallêflintas (2)—Squarish, about 13 dia.
Dolerite—Coarse ; several about.
Granite, resembling Eskdale—About 12 dia., rounded.

The pigstye has for its foundations three very large Boulders, one an Andesite and the other a Syenite, also a large Felsite. One block looks as though it had been hewn and shaped by human hands, and presents two plain, smooth, angular faces.

At Corner of Cross Roads by Pelsall Farm (Level 490).

In bank is a large rounded Boulder, while there are several others, all of the usual types, near the White Lion on the Brownhills Road, and you may follow their track on both sides of the road with conspicuous occurrences near York's Foundry, in the neighbourhood around High Bridge, in garden banks opposite Yew Tree Tavern, Jollier Collier Inn, Swan Inn, and Lodge Farm. A roadside heap of stones, collected from surrounding fields and lying near High Bridge on the Brownhills side, consists of little other than Erratics from 2 to 4 dia., rounded and subangular in shape. The superficial deposits of this district are no doubt deposits of glacial drift or boulder gravel.

Near Canal Bridge, High Heath.

C. Granite—18 cir., 7 by 5, elliptical, surface rough.
ditto 16 cir., 6 by 6, round, rough.
Andesite Ash—12 dia., with Lapilli, sub.
Syenite—10 dia., sub.
Several Felsites.

In garden bank near Yew Tree Tavern.

12 Erratics.

Near Jolly Collier.

8 Erratics.

Near White Lion Inn, Brownhills Road.

Andesites (2)—16 by 13, sub.
ditto (1)—18 by 16, sub.
Syenite (1)—15 by 14, sub.

In garden bank opposite Swan Inn.

20 large Erratics—Andesites, Syenites, Felsites, Granites, and Volcanic Ashes.

WYRLEY AND NORTON TO BROWNHILLS.

On both sides of the road between Great Wyrley Railway Station on the London and North-Western Railway to Brownhills London and North-Western Railway Station, a distance of about five miles, there is a constant occurrence of Erratic Blocks varying in size from an inch or two in dia. to several feet. Roadside heaps of stones *en route* consist for the most part of Erratics, as do also the stones occurring in the surrounding turf and arable fields, which may be called Boulder Gravel.

In hedge bank near Mr. J. T. Hatton's, Brook House, Wyrley.

Andesite—12 by 6, sub.
ditto 9 by 6, sub.
B. Syenite—10 by 4, sub.
ditto 8 by 4, sub.

In brook course.

Andesite Ash—18 by 12, flattish, edges rounded.
Syenite—24 by 16, sub.

By drive gate.

C. Granite—16 by 12 by 49 cir., with deep cut 12 long, rounded, coarse surface.
B. Syenite—12 by 10.
ditto 24 by 16 by 76, sub., rather flattish surface, scratched.
ditto 18 by 15—sub.

At junction of cross roads, opposite Ivy Cottages.

B. Syenite—20 by 16, sub., roughish surfaces.
ditto 20 by 12, sub., ditto
E. Granite—18 by 16, sub., ditto, probably Eskdale.
B. Andesite—12 by 8, angular, surface smooth.

In Mrs. Dacey's yard, back of Ivy Cottages.

Syenite—12 by 8, sub.
B. Andesite Ash—12 by 7, oblong, rounded angles.
ditto 10 by 8, angular.
Red Sandstone, like Torridon—8 cir., rounded.
B. Syenite—16 by 12 by 8, sub.
Grey Syenite—12 by 9, sub.
Q. Felsite, 12 by 9, squarish, with flat surface smoothish.
20 Erratics in a small retaining wall in pathway leading to back of cottages called The Willows, on the Churchbridge side.
Also several at drive entrance to house with timber yard adjoining, and near the Institute.

In road at corner opposite Institute.

Syenite—About 8 dia., rounded.
Andesite—About 12 by 9, rounded.

Andesites, Syenites, and Granites in cottage gardens and in garden banks near Institute.

By blacksmith's shop.

Syenite—12 by 8, sub.

In bank by field gate opposite.

Syenite—14 by 12, sub.
Andesite—12 by 5, sub.
Syenite, Grey—12 by 8, sub.
Quartz Block—11 dia., rounded.

A roadside heap of broken stones in lane near blacksmith's shop included Andesites, Syenites, Granites, Andesitic Ashes, Dolerites, Felsites, Sandstones, and Quartzites. On another heap, a little further along the lane towards Norton, I counted 20 Criffel Granites and 8 pieces which resembled Eskdale Granite. The Criffels were from 2 to 5 in dia., and mostly rounded, with rough surfaces, the quartz crystals standing out prominently in most of them. The term Criffel applied to these Granites may be doubtful, since one of my test specimens taken from this locality and resembling above was proved to be Syning Gill Granite.

At stile near farm.

B. Andesite—16 by 10, angular.

In garden and field banks opposite.

A large number of Boulders.

At corner of wall leading to entrance of foldyard opposite cottages.

Syenite—36 by 24 by 96 cir., sub., irregular surface.

Cottage front garden opposite.

C. Granites (2)—About 12 dia. each, rough.

Low white cottage in lane.

4 large Erratics in yard pavement.
1 E. Granite near.

Roadside heap of stones junction of roads to Wyrley, Churchbridge, and Norton, principally Erratics.

Retaining wall of brook course on Norton Road.

B. Syenite—12 dia., rounded.
ditto 16 dia., ditto
Andesite—14 dia., angular.
C. Granite—10 dia., rounded.
C. Sandstone—13 dia., rounded.
And many others.

Side of road near farm cottage.

B. Syenite—12 by 8, sub.
Hêlleflinta—14 by 9, angular.
B. Syenite—9 dia., rounded.
B. Andesite—10 by 9, oblong.

Corner of Cannock and Leacroft Road.

B. Syenite—in cottage garden.
ditto 12 dia., rounded.
ditto 10 dia., ditto

On side of road by gate into Mr. Masfen's field rickyard.

Syenite—29 by 24, angular.
Andesite—24 by 16, triangular.
ditto 24 dia., scratched, roughish.

Near one of Mr. Masfen's labourer's cottages.

3 large heaps of broken stones, 6 yards by 4 yards, composed principally of Erratics.

Corner of cart shed.

B. Syenite, 16 by 12 by 12 deep, uneven surface, rounded angles.

In retaining wall opposite cart shed and house.

Hundreds of Erratics—8 to 16 dia.
Andesite—36 by 24, broken surface, squarish shape, rounded corners.
The paved yard leading up to Mr. Masfen's foldyard side of house includes many Erratics, with two large ones on each side of entrance.

In road at cross roads leading to Norton Hall.

B. Syenite—12 dia., rounded.
ditto 10 dia., ditto
Andesite—12 by 8, E.L.

Corner of stables at Fleur de Lis.

Andesite—12 by 12, rounded, E.L.
B. Syenite—24 by 16, rounded.

Roadside near Fleur de Lis.

B. Syenite, 24 by 17, rounded block, surface rough.
ditto 9 dia.

Around disused pond in field adjoining above.

7 large Erratics—12 up to 24 dia., rounded.

In lane towards farm at Cross Roads.

Syenite—20 by 18, rounded, E.L.
C. Granite—36 by 24, nearly buried in bank, rough and irregular surface, about 500 yards S.E. of Fleur de Lis, and about 60 yards from milestone, N.W.
There is a long cinder wall extending in N.W. direction from stile in Norton Lane towards Fleur de Lis, which includes many Erratics.

Near stile leading across fields to Norton Hall.

C. Granite—8 by 6, rounded, rough surface.
Syenite—10 by 9, sub.

In roadside nearly opposite stile.

Large B. Syenite—36 by 33, about 114 cir., corners all rounded, surface roughish, irregular, and uneven.

An examination of an arable field here revealed the presence of a general occurrence of small Erratica, which may be considered Boulder gravel.

On opposite side of road.

Andesite Ash—16 by 12, flattish, angular.

Around finger post at cross roads by Pinfold, leading to Brownhills, Norton, Wyrley Grove, and Wyrley.

28 large Boulders, including—
Grey Syenite—16 by 16 by 60 cir., rounded.
Probable E. Granite—16 by 12, rounded.
Andesite—12 by 11, sub.
Andesite Ash—16 by 10, sub.
B. Syenite—24 dia., triangular.

In garden retaining bank at Farm Cottage, opposite.

About 30 smaller Boulders, from 12 to 17 dia.
C. Granite—16 by 16 by 60, near, rough surface.

Little Norton.

Several Andesites, Syenites, and 3 C. Granites, about 8 and 9 dia. up to 12.

Further along the road towards Conduit Old Offices.

Andesite—12 by 9, E. L.
ditto 12 dia., E. L.
B. Syenite—11 dia., sub.
ditto 16 dia., ditto.
ditto 24 by 12, oblong.

Roadside heap of broken stones, 4 yards by 4 yards, include several chips of Boulders.

Near Turf Tavern (Level 462).

B. Syenite—12 by 8, sub., edges all rounded.
ditto 16 by 8, sub. ditto
B. Andesite—20 by 12, sub., ditto

Canal Bridge.

On the canal bridge there happened to be an accumulation of large stones, 30 in number, from 6 to 13 in dia., round and oblong in shape, all of which were Boulders of the Andesite and Syenite types collected in the neighbourhood.

Near Old Conduit Colliery.

B. Andesite—19 by 10
ditto 12 by 8
Syenite—16 by 12
ditto 11 dia.
} Rounded blocks.
Several smaller ones.

Roadside heap of broken stones opposite Conduit Offices included a large number of Erratic fragments. The fields here are strewn with Boulder gravel.

Near Price's Conduit Farm (Level about 510)).

B. Andesitic Ash—18 by 12.
ditto 16 by 14.
B. Syenite—12 by 9.

On Common between Rising Sun and Crown Hotel (Level 511), in the direction of Brownhills.

Q. Felsite—12 dia.
ditto 9 dia.
Andesites—Several, E. L.
Syenites—ditto.
C. Granites (2).

Heap of large unbroken stones included many small Erratics, among which were E. L. Granites.

Outcrop of Yard and Shallow Coal at Brownhills.

At coppice side, Brownhills, about 300 yards north of Big House Farm, there are some coal open works, where the Yard Coal outcrops to the south along a line nearly 300 yards. It dips to the north at the rate of 2 inches to the yard. A portion of the outcrop is bare, being denuded of all overlying material, and the coal, which has simply to be dug out, is consequently softer than it is where covered. The coal is very like Brooch Coal, but is locally called Yard Coal, averaging about one yard in thickness. It is generally overlain by a bat or shale of a soft crumbling nature, due probably to its nearness to the surface, on which rests a layer of blue coal-measure clay, averaging about 2 feet in thickness, and containing small nodules of clay ironstone. This is superseded by a layer of yellow boulder clay, about 6 feet thick, in places shading off into the blue clay, the bottom of which is a pure ochre, very tenacious, but the top of which is impure and impregnated with sand and stones. This in turn is covered up with a deposit of gravel, varying in thickness from one foot to 18 inches, and containing erratics generally of small size, but some have been taken out, so my informant, Mr. John Owen, said, as large as a man's head. The Shallow Coal outcrops at a distance of about 500 yards S.E. of this point, having been proved in some recent cellarage excavations at the Swan Inn, on the Pelsall Road. Mr. Owen also told me that he had worked the Shallow Coal a hundred yards from the "Swan," at a depth of 8 yards from the surface, which 8 yards consisted (with the exception of a few inches of top soil) entirely of glacial drift gravel that lay upon the shale of the Shallow Coal without any intervening boulder or coal-measure clay whatever. Many rounded blocks of hard rock, Mr. Owen says, were taken out of the gravel, most of which were thrown back again into the shaft when it was filled up. I called his attention to several blocks a score or so yards away, about 9 to 10 inches in diameter, rounded and subangular, which he says resembled some he saw taken out of

of the pit gravel, and which are undoubted erratic boulders from the English Lake District, and of the usual types.

Brownhills (Level 495).

On Common at Watling Street, near Mission Church.

A. Andesite—Large Coarse Grained, 31 by 33 by 92, sub.

About Common.

Several smaller Andesites and Syenites.

Ogley Square.

C. Granite—About 12 dia., rounded.
A. Andesite—12 by 12 by 20.
ditto 18 by 13 by 10.
B. Andesite—21 by 15.
ditto 20 by 16.
Syenite (Buttermere)—16 dia., rounded, fine grained.
ditto 35 cir., coarse, rounded.
Several smaller Andesites and Syenites.

Friezland Lane, Catshill.

C. Granite—24 cir., rounded, rough surface.
ditto 21 cir., ditto ditto
ditto 23 cir., ditto ditto
ditto 16 cir., ditto ditto
B. Syenite—45 cir., smooth surface, rounded.
Andesite—54 cir., rough, sub. angular.
Several angular blocks of Basalt and Dolerite.
A roadside heap included many small boulders of Andesite, Ash and Syenite, there were also some Peldon blocks local. There were 5 large boulders in a potato garden, one of which, a Syenite, measured 45 in circumference.

Wilkin, Brownhills.

Syenite—16 by 14, sub.
Andesite—25 by 20, sub.
ditto 16 by 12 by 36, angular.
ditto 21 by 16, sub.
ditto 19 by 16, sub.
A. Andesite—12 by 8, oval, weathered very white.
ditto 9 by 6, rounded, ditto
Syenite—16 by 12, rounded.
ditto 24 by 16, angular.

Albuts Road, Wilkin.

Andesite—27 by 21 by 13, deep, flattish.
ditto 20 by 19 by 38, sub.
Syenite—16 by 12, sub.
ditto 18 by 15, sub.

Brownhill Common, towards Norton.

Andesite—135 cir., 45 long by 36 across, rough surface.
ditto 55 by 43 by 150, egg shaped, ditto
ditto 27 by 19 by 72, rounded.
Syenite—32 by 33 by 84 cir., rounded.
Andesite (Augite)—38 by 26 by 99, egg shaped, rough surface.
Hard white close grained Sandstone—36 by 26 by 92 cir., uneven surface.

Photographed.

Around lamp-post opposite Hussey Arms.

Andesite—About 18 dia., sub., edges rounded.
Syenites (2)—16 by 10 dia., sub., edges rounded.

On heaps of broken stones on Common near Congregational Schools.

Andesite—numerous pieces.
Andesite Ash ditto
Syenite ditto
Q. Felsite ditto
C. Sandstones ditto
Dolerite—several.
C. & S. Granite—several.

Near Big House Farm, Mr. J. Owen's.

C. Granite—9 dia., rounded, rough surface.
Andesite—18 by 10, sub.
Syenite—12 by 9, E.L.

Heap of stones near.

6 small probably E. Granites—3 to 4 dia., and large number of other Erratics.

At corner of Common Road, near lamp-post.

B. Andesite—16 to 10, sub.
Syenitic Granites and Eskdale Granites on heap of stones near.
Many other large Boulders on common towards Midland Station.

NOTE.—Boulders are of common occurrence around Brownhills, and are of the usual Andesite and Syenite type with Granites. On the Norton side probably Eskdale Granites first appear, and on the common towards Norton East they become plentiful. A roadside heap of stones near the Wilkin consisted of little else but Erratics, it being the exception to find one that was not. It would be impossible to catalogue the Boulders in the neighbourhood of theWilkin, as they occur in every garden and field and at every corner and in every bank. Criffel and Skiddaw Granites, too, are plentiful.

No. 1 road by side of road near field belonging to Conduit Colliery Co., Norton Green.

A. Andesite—43 by 40 by 96, sub., weathered white and scratched.
ditto 32 by 20, angular, rounded edges.
ditto 30 by 23, flattish, weathered light brown.

Andesite—33 by 24 by 24 by 76, rounded, weathered white, very hard, and rings when struck like a Skiddaw musical stone.
ditto 31 by 24 by 70, egg shaped, hard, and rings, looks as though scratched.
ditto 18 by 12, angular, compact.
A. Andesite—18 by 13, sub.
ditto 21 by 19, egg shaped, very white surface.
B. Syenite—36 by 24, rounded edges.
ditto 22 by 16, sub., smoothish.
Ash—23 by 15, sub., heavy, coarse.
Ash—17 by 12, sub., ditto
Carboniferous Sandstone—21 by 13, angular.
ditto 17 by 10, flat.
ditto 20 by 19, sub.
ditto 19 by 16, sub.
ditto 20 by 12, sub.
Syenite—22 by 21, rounded.
ditto 21 by 20, ditto
Ash—16 by 20—squarish, rough.
Dolerite—18 by 16, sub., coarse
ditto 21 by 20, sub., ditto
Syenite—14 by 15, with quartz, sub.
ditto 28 by 19, ditto sub.
E. Granite—12 dia., rounded.
ditto 14 dia., ditto
ditto 10 dia., ditto
ditto 8 dia., ditto
C. Granites—10, rounded, indented surface.
ditto 9, ditto ditto
S. ditto 16, ditto ditto
ditto 13, ditto ditto
ditto 6, ditto ditto
Flints—Several in field adjoining.
Scoreaceous Lumps—Several in field adjoining.
Felsites—Several.

Note.—The Conduit Colliery Co. ploughed up a field for the first time last autumn abutting on this road and near the railway line, and it was found to be full of Erratics, large and small. Some were with the greatest difficulty removed. Andesite Lavas and Ashes, with Syenites, Granites, Felsites, Dolerites, Flints, Carboniferous and other Sandstones, and Pumiceous Lavas make up an extraordinary assemblage of rocks whose local distribution is very extensive and indicative of the probable presence of an ancient terminal moraine. A roadside heap of stones near this field, measuring 9 yards by 4 yards, and 18 inches deep, was composed entirely of Erratics, conspicuous amongst which, for the first time in my observations, were the probable Eskdale Granites.

In Fields near Fair Lady Colliery, Five Ways (Level 505).

B. Syenites—75 by 66 by 180 cir., sub.
ditto 41 by 41 by 113, cir., triangular, appears scratched, rounded corners.
A. Andesite—36 by 33 by 101, rounded.
Syenite—14 by 12, rounded.
Andesite—15 by 10, rounded.
Ash—14 by 11, rounded.
Andesite—51 by 41 by 126, sub.
ditto 19 by 14 by 40, sub.
Syenite—24 by 23 by 64, rounded, smooth surface.
ditto 12 by 9 by 29, coarse.
ditto 21 by 22 by 48, covered with hard, stony substance, and whitish colour.
ditto 52 by 42, angular.
ditto 38 by 24, flat on three sides, somewhat rounded under surface.

Gateway corner by incline up to Pits.

40 large and small built into a bank forming a retaining wall.

Near Pits.

Andesite—63 by 123 cir., covered with hard till, sub.
White Quartz—16 by 15 by 46, flattened on one side, rounded corners.

Cross Roads, Ball's Mount, towards Five Ways (Level 562).

Q. Felsite, 12 by 10, sub.
Syenite—11 by 10, sub., scratched.
C. Sandstone—13 by 11, sub.
C. Granite—12 by 8, sub., rough surface.
Hard White Sandstone—13 by 9, sub.
Andesite—12 by 8, weathered white.
Syenite—14 by 10, rounded.
Limestone—24 by 14, angular, near Sankey's corner.

By Wooden Stables on Common.

A. Andesite—14 by 12 by 9, flat, edges rounded.
Andesite Ash—36 by 32 by 81 cir., rounded.

Note.—Everywhere from Burntwood to Wooden Stables Farm, Boulders occur as coping on either side of the road, footpaths, or in the fields and fold-yards. A large heap of roadside stones near Wooden Stables, gathered from the surrounding fields, presented *en masse* a bleached appearance, and included Quartzites, Felsites, Bunter Conglomerates, Grits, Sandstones, liver-coloured Quartzites, with several Andesites, Syenites, and Granites.

Cannel Coal in situ (Level about 650).

Near No. 8 Pit of the Cannock Chase Colliery Co.

Cannel Coal—Outcrop of about 8 inches thick, and several hundred yards in extent.

Erratic Cannel Coal.

Note.—During the recent sinking of the shaft of the new Fair Lady Colliery for Mr. Hanbury, M.P., Mr. Charles Fisher, the engineer, discovered in the drift gravel at a depth of about 8 yards several loose pieces of Cannel Coal, derived probably from the Cannel occurrence near No. 8 Pit of the Cannock Chase Co. I have one piece triangular in shape, measuring 9 inches by $7\frac{1}{2}$, flattish, one surface uneven, with conchoidal fractures, the other smoothed and beautifully striated. Brown chocolate clayey material adheres to it, levelling up the glaciated groovings and interspaces.

Boulder Clay on Cannock Chase.

Note.—According to Mr. Sopwith, C.E., F.G.S., a bed of yellow boulder clay, estimated roughly at between 5 and 6 feet thick, occurs everywhere beneath the drift gravel on Cannock Chase, at a depth of from 12 to 15 yards. It rests upon a bed of bluish indurated coal measure clay, varying between 3 and 4 yards in thickness. This corresponds to a clay mentioned to me by Mr. Charles Fisher, manager of the Coppice Collieries, as occurring everywhere on the Chase at the base of the drift. He describes it as a hard, strong clay running in slaty layers of a greyish or yellowish colour. The yellowish clay would represent the boulder clay, and the greyish the upper coal measure clay beneath it. There is apparently no vein of other material dividing the clays which shade off into each other. It was in the drift gravel above the boulder clay that the erratic blocks of Cannel Coal were found.

Five Ways (Level 597).

Note.—Boulders occur generally and thickly on the ground between Norton East and Five Ways, and are principally Andesites, Syenites, and Ashes, with Granites, Felsites, and Quartzites. It is questionable if there is a field or garden in which they are absent. Some are of very large size, measuring as much as 12 to 15 feet in circumference, while others are smaller, down to 12 inches in circumference, and may be seen cropping out of the ground at all angles, but they thin off sharply on the road towards Wimblebury just as you leave Five Ways Schools. On the road towards the Trafalga Inn one passes through a cutting of drift material, in which the stones occur irregularly. The road falls to to the north, forming a deep hollow just past the Lamb and Flag, Wimblebury. Cannock and Rugeley Co's. Wimblebury Colliery is in this hollow, and to the north-west of it is a large exposure of white sand. There is also an occurence of Boulder Clay here.

By Trafalga, at corner cross roads opposite shop.

Large angular Grit or Ash—24 by 12.

Also opposite corner.

Large angular Grit or Ash—24 by 24, flattened, and rounded corners.

Corner of Rawnsley Road, opposite Edward Baxter's shop.

23 Erratics—ranging from 10 to 18, rounded and sub.

From this point, past Mr. Williamson's house and the Schools and down to Red Moor Brook Bridge, thence along the road to the Red Moor Inn and up over the hill to Gentleshaw Church and Castle Ring, boulders may be said not to occur. I saw no trace of a true erratic. Between the schools and the brook I saw here and there one, but around the brook bridge, and course where I expected to see many, I found only quartzites, belonging probably to the Bunter series. At the foot of Red Moor Hill the local rock is a hard whitish sandstone, weathering quite black. The base is a hard red Bunter sandstone rock, while the capping is of gravel. A heap of roadside stones in this neighbourhood presents a yellowish appearance, with large grits a foot long and of oblong or oval shape; others are of dark blueish iron colour. From Gentleshaw to Chorley Schools, *viâ* Brook Farm, no boulders occur excepting near Chorley Schools, where there is a fine Skiddaw Granite.

Chorley Schools, in bank near.

Skiddaw Granite—20 by 16, rounded, rough surface.

In lane near Burntwood.

Andesite—12 by 6, angular.
ditto 16 by 15, rounded.
ditto Ash—12 by 9, sub.

Extraordinary Discovery at Cannock Wood.

Boulders Embedded in the Shallow Coal.

Twenty-four years ago, during the summer of 1872, two crystalline rounded blocks, the larger 9 inches and the smaller 7 inches in diameter, were discovered embedded in the Shallow Coal at a depth of 185 yards at Cannock Wood Pit, the property of the Cannock and Rugeley Colliery Co., Limited, within 1,200 yards of Castle Hill, and about 1,800 yards on the western side of the eastern boundary fault. They were of a darkish grey colour internally, probably Syenite, and their surface was smooth and looked as though polished with black lead. Mr. Peake, sen., the then secretary of the Colliery Co., took one of the Boulders to Professor Bonney, at Rugeley, and the other was retained by Mr. Williamson, the general manager. Mr. Williamson thinks Professor Bonney removed his specimen to Cambridge, where it probably now is, and promised to report the discovery to the Geological Society. Mr. A. Sopwith, F.G.S., of the Cannock Chase Collieries, has, however, looked up the transactions of the Geological Society of that time, but cannot trace any record of the discovery. Mr. Williamson saw the cavity in the solid coal out of which one of the blocks was taken. It was basin-shaped. He instructed his workmen to carefully cut the cavity out, but they failed, the coal splintering under the operation. Mr. Peake, jun., manager of the Walsall Wood Collieries, saw the boulders at the time, and corroborates Mr. Williamson's description of them. I happened to get to know of this discovery through talking to Mr. Williamson on the subject of boulder distribution. Sir Archibald Geikie refers to an almost similar dis-

covery of an angular block of Lava (Diabase) on a coal seam surrounded by fire clay in the stratified deposits on the coast of Fife. See *Class-book of Geology, Records of Volcanic Explosions*, page 137.

Boulders in the Drift Gravel.

In boring at the Cannock and Rugeley Colliery Co.'s Valley Pits, commonly known as the Pool Pits, a bed of Boulders 9 feet in thickness was struck, about 45 yards beneath the surface, lying on a bed of fine gravel about 20 yards in thickness. Below this bed were the coal measures, and at a depth of 12 yards further down, or 77 yards from the surface, "the old man's coal" was struck, and proved to be 6 feet 6 inches in thickness.

ADDITIONAL NOTE—30th SEPTEMBER.

Superficial Deposits of Hammerwich.

During this summer, 1897, the South Staffordshire Waterworks Co. have been making excavations 3 feet deep, extending from Hammerwich Cottage Hospital to Hammerwich Village, distance perhaps a mile, for the reception of a water main, and in doing so they passed through alternating occurrences of marl, fine sand, gravel, conglomerate, and hard variegated sandstone rock. The marl contained stones irregularly deposited, and occurred in patches *en route*. It is a strong chocolate-coloured marl, sectile and tenacious and similar in character and composition to the other marls of the neighbourhood as well as to the Keuper marl itself. The gravel is a drift gravel, occurring in pockets, while the conglomerate and variegated sandstone occurrences appear to be parts of the regular bedded Bunter series. Many of the stones occurring in the marl and drift gravel on examination proved to be erratic blocks of igneous material from the English Lake district. They were of the usual shapes, angular, subangular, rounded, and elliptical, and several bore striæ in the direction of their longest axes. They consisted for the most part of Andesites, Syenites, Hornblende Granites, and Andesitic Ashes, associated with local Quartzites and other rocks of the Bunter conglomerate. The presence of these true erraties, many of which were remarkably well-preserved specimens, have set at rest any doubts I may have had as to the real nature of the superficial deposits of this district.

The erraties were usually of small size, of which the following are examples:—

H. Granite—11 by 6 by 26, sub., smooth surface.
Grit—7 to 5, flattish.
A. Ash—10 by 7 by 22, smoothish surface, sub.
A. Andesite—9 by 6 by 23, elliptical, surface smooth.
B. Syenite—7 by 4 by 16, angular.
Fine Andesitic Ash—7 by 7 by 3 by 23, triangular, with rounded edges and smooth surface.

Q. Felsite—8 by 6 by 16, rounded.
Andesite Lava—8 by 4, oval-shaped, vesicular structure.

Near Mrs. Venables' Cottage.

B. Syenite—About 12 by 10 sub., surface roughish and pitted.

Conclusion.—It will have been noticed that I have catalogued the occurence of other things than boulders, clays, and gravels of the Glacial drift period, the object being to chronicle every item of interest observed in my investigations.

Notes on the Microscopic Characters of some Rocks occurring as Erratics in the Lichfield District. *

By W. S. Boulton, Assoc.R.C.S., F.G.S.,

Lecturer on Geology in the Mason College, Birmingham.

I have personally examined specimens of all the erratic blocks described by Mr. Mantle in the foregoing paper, and in many cases have examined the boulders *in situ*. Some of them could at once be recognized and referred to their original home; while others, viewed macroscopically, appeared somewhat doubtful. I suggested, therefore, that sections of some of the doubtful types should be cut, and a careful microscopic diagnosis made. For I hoped that such a microscopic examination would not only throw light on the composition and structure, and therefore the source, of the erratics described in the present paper, but might possibly assist future observers in correlating erratics and mapping dispersions in the Midlands generally. With this object, I have had about thirty slices cut, including specimens from most of the localities named in the foregoing catalogue.

Granites.—Since granite boulders are very common in the Lichfield district, as well as in other areas in the Midlands, specimens from all varieties found were selected for cutting. In the field they were provisionally described as of two types, the Criffel type, from the Galloway district of South Scotland, and the Eskdale type from the Lake district of the north of England. A careful microscopic examination of these granites, and a comparison with rocks found *in situ* both in the Criffel mass and in the various masses of the Lake district,

* Appendix to Mr. H. G. Mantle's Paper.

have shewn, however, that while the Criffel granites are undoubtedly largely represented in the district in question, no certain Eskdale specimens have been found. Specimens [8] and [23] which were thought to be Eskdale, turn out to be Criffel and Skiddaw respectively, the pink colour being due to a local staining of ferric oxide. To make quite sure of this, I sent [8] and another, [4] to Mr. Teall, who very kindly informed me that both specimens came from the Criffel mass. I think it quite possible that granites of this texture and colour found in the Midlands have been hastily put down as Eskdale, when in reality they are iron-stained varieties of granites from quite different localities.

Some specimens of granite ([2] [3] and [26] for example) appeared to differ from the Criffel type, and Mr. Mantle suggested that they bear a marked resemblance to those of Syning Gill, in the Skiddaw area, specimens of which he had in his collection. As will be seen from the detailed description given below, there can be little doubt that they come from the same Skiddaw mass as the Syning Gill rocks. We have in the Lichfield district, then, two types of granite, the Criffel and the Skiddaw. If the Eskdale type does occur, specimens of it have yet to be identified.

Syenite.—Good specimens of the Buttermere Syenite of Ennerdale are found, shewing all the constituents, and the beautiful granophyric structure, so characteristic of that rock.

Andesites and Andesite-Tuffs.—These rocks occur plentifully and in many varieties, and doubtless belong to the well-known Andesite group of the Borrowdale series. All these rocks are considerably altered, both in their mineral constituents and structure, and a satisfactory description becomes, therefore, a very difficult matter. Moreover, until the Borrowdale series has been worked out in more detail, it will be impossible to precisely place these travelled blocks. It is worthy of notice that, when cut, nearly all the Andesite rocks turn out to be Ashes or Tuffs, often composed largely of crystalline aggregates. At the same time I am fully aware of the great difficulty often experienced in distinguishing between a very decomposed massive crystalline rock and a

correspondingly altered crystal-tuff of the same series. When not Tuffs, the rocks of this group are Augite or Hornblende Andesites.

Rhyolites or Felsites.—Pink, hard, siliceous, compact rocks, which were described in the field as Felsites, shew under the microscope a distinctly ashy or tuffy structure, and should therefore be described as Felsite or Rhyolite Tuffs. In some cases the fragments are distinctly rounded by water action, while in others, again, a well marked though somewhat irregular bedding is clearly visible. The source of these acid tuffs is somewhat doubtful, for rocks answering to them have been described in the Borrowdale Series, and I myself have got sections of Shropshire Uriconian Tuffs which are practically indistinguishable from the specimens described below. Bearing in mind the preponderance of Lake district and south Scottish rocks, and the absence of Arenig rocks, in the Lichfield group of erratics, it would seem safer to assume that these Felsite Tuffs have also come from the same northern area, rather than from Shropshire or North Wales.

There can be no doubt that we are dealing with a Lake District Dispersion, for all the specimens collected so far, with the possible exception of the Felsite rocks already referred to, come either from that district or the south of Scotland, or are rocks from the Carboniferous series which were picked up immediately to the north-west of the Lichfield area.

No Arenig rocks, which are so plentiful to the west and south-west, have as yet been found, so that the line separating the North of England and North Wales dispersions must lie immediately to the south-west of the area we are considering.

The following is a brief account of the more important microscopic characters of some of the rocks examined :—

I.—Granites.

[8] From Norton Canes. Pinkish grey granite, rather fine grained, and with Hornblende and Biotite clearly visible in hand specimens. Under the microscope, much massive Orthoclase is seen, though sometimes idiomorphic crystals occur. These some-

times show zoning, as do the Plagioclase crystals, which occur in fair abundance. Quartz is rather poorly developed and much cracked with many inclusions. Biotite is not plentiful, and the crystals in some cases are bent and frayed out, as if by pressure; and somewhat decomposed, with Magnetite grains along cleavage planes. Hornblende occurs in about the same proportion as Biotite, and several yellow wedge-shaped crystals of Sphene, together with many crystals of Apatite.

Hornblende-Granitite—Criffel.

[4] From Chorley. A somewhat fresher rock than [8] and paler in colour. Orthoclase occurs in many idiomorphic crystals, together with some Plagioclase. Quartz is fresh, and shews many enclosures in more or less parallel lines, some lines traversing adjacent crystals. Biotite is generally surrounded by Hornblende, and therefore crystallized out before the latter mineral, and its borders are often black with Magnetite particles. Sphene and Apatite occur, the latter enclosed in Hornblende and Mica crystals.

Hornblende-Granitite—Criffel.

[5] Same rock as above, but with much Sphene occurring in yellow massive, irregular, and sometimes broken crystals.

[27] From Chorley Schools. Fresh-looking, pale, pinkish-grey granite with Orthoclase, some Plagioclase, Biotite, and Hornblende, the last mineral sometimes enclosing the Biotite. Sphene plentiful with few crystals of Topaz and Apatite.

This rock is very like [4].

Hornblende-Granitite—Criffel.

[21] [24] [25]. Specimens from Syning Gill (Skiddaw) for comparison. The rock is a light grey or white granite with much massive Orthoclase, which occurs in large white crystals. Some Plagioclase is present, together with much Biotite, in places changing to a green chloritic product. Quartz is present in fair quantity, and is occasionally idiomorphic with respect to the Orthoclase.

[22] From Pipe Place. [28] From Pipe Place. [23] From Pelsall. [26] From Jackson's Farm. [36] From Longdon. These five rocks contain much Orthoclase, in big white crystals, with some Plagioclase and much Biotite and Quartz. [23] is considerably

stained with ferric oxide, which has penetrated along the cracks. [36] possibly contains a little Hornblende and Topaz, and some of the quartz crystals are idiomorphic with respect to the Orthoclase.

All these rocks are probably from the same mass, and correspond, in almost every particular, with the three specimens obtained *in situ* from Syning Gill and described above. Thus they have large white Orthoclase crystals, with fairly large blebs of Quartz and much black Mica. Under the microscope they shew some Plagioclase, and occasionally the Quartz is idiomorphic with respect to the Felspar. The Biotite in some cases has degenerated into a green chloritic product. They are certainly not Criffel, for they are more acid than the granites from Galloway, and contain no Hornblende or Sphene. [23] was, when collected, described as Eskdale, but I have already pointed out that the microscope at once shews that the specimen is stained with ferric oxide, especially along the cracks. Moreover, apart from colour, this rock, together with the others grouped with it, contains so much Biotite, and the relations of the Quartz and Felspar are such, that the possibility of their being Eskdale may be dismissed. We may safely conclude that they are of the Skiddaw type.

II.—Syenite.

[6] From Five Ways. [31] From Ivy House Farm. [33] From Lichfield Gas Works. These are all the typical pink Buttermere Syenite, shewing the characteristic intergrowth of Quartz and Felspar. Biotite and Hornblende are both present, but in small quantities, and both are much decomposed into a green chloritic mineral. Magnetite is scarce, and often aggregated round the ferromagnesian constituents.

Quartz-Syenite or Granophyre—Buttermere.

III.—Andesite Rocks.

[10] From Norton. Dark, bluish-green, fine-grained rock with yellow felspar crystals, visible macroscopically. Under the microscope it is seen to be much decomposed, and made up largely

of crystals of Orthoclase and Plagioclase, with lapilli of fine felspathic ash, all set in a ground mass of fine felspathic dust. Much stained with epidote.

Andesite Tuff or Ash—Borrowdale Series of Lake District.

[3] From Five Ways. Very decomposed with much secondary epidote and quartz. The Amphibole is now almost entirely converted into Chlorite and Epidote. Between crossed nicols, the rock is seen to be largely made up of a felted mass of Plagioclase crystals, shewing the compound twinning well. It is possibly an Andesitic crystal-tuff, but more probably a rather coarse Hornblend Andesite.

Hornblende Andesite—Lake District.

[11] From Five Ways. Compact green rock with black, often round, patches, and looking like a vesicular Andesite. Microscopically the round patches are seen to be filled with yellow and nearly colourless granular and acicular epidote, and a green chloritic looking mineral, and have round them a border or ring of magnetite grains. In the matrix are a number of large crystals of Plagioclase, which become visible between crossed nicols. It is just possible that the "vesicles" are spaces originally occupied by some ferro-magnesian constituent, which has been removed and subsequently replaced by chlorite, magnetite, and epidote.

Andesite—Lake District.

[7] From Five Ways. Dark greenish-grey rock, with conspicuous squarish felspar crystals, and looking generally fresher than most of the other Andesite rocks. Microscopically it has a ground mass of small Plagioclase and Hornblende crystals, with large porphyritic crystals of the same minerals scattered plentifully through it. The felspars, especially, are crowded thickly, and always shew polysynthetic twinning, and are much decomposed, a small unaltered portion in the centre of each crystal generally retaining the twin-structure. The hornblende crystals are plentiful, and many are cut nearly at right angles to the P. A., and shew the prismatic cleavage remarkably well; while others cut parallel to the P. A. shew one set of twinning planes, and are rectangular in shape. Many of these hornblende crystals shew signs of con-

siderable chloritization, with the formation of peripheral portions of a pale brown fibrous variety in optical continuity with the comparatively unaltered hornblende, and shewing about the same pleochroism. It is this substance which in places suggests the presence of mica. Secondary quartz and some epidote are present in the ground-mass, and in cavities in the porphyritic constituents.

Hornblende Andesite—Lake District.

[12] From Five Ways. Pink and green, finely crystalline, syenite-looking rock, very decomposed and much stained with epidote. Possibly contains lapilli of scoriaceous Andesite.

Andesite Ash—Lake District.

[29] From Hilton. [30] From Hilton. Dark green rock with small black patches. Microscopically, seen to be much decomposed, the whole ground-mass being spotted with secondary magnetite grains. Some mineral, possibly Augite, has been wholly or partly removed, and the spaces left filled with epidote, and a fibrous, green, chloritic mineral. Between crossed nicols the ghosts of Plagioclase crystals become visible. The rock is much like [11].

Andesite—Lake District.

[34] From Wilkinson's Garden. Very decomposed rock, looking like crystal-tuff of Andesitic composition. Plagioclase and Hornblende crystals can be recognised. Rock appears to have been crushed, and contains much secondary quartz.

Andesite Ash—Lake District.

[35] From Ivy House. Dirty green, finely crystalline rock, of syenitic or andesitic aspect. It contains porphyritic crystals of Orthoclase and Hornblende, and granules and rods of Epidote. Between crossed nicols, the ground-mass is seen to be made up of a felted mass of felspar crystals, mostly Plagioclase. The Hornblende has a chloritic look, and the edges of the crystals are ragged. Magnetite has collected plentifully round crystals of hornblende and apparently round crystals of apatite in some places, forming black rods. The rock might almost be termed a finely-porphyritic Syenite.

Hornblende Andesite—Lake District.

IV.—Felsite Rocks.

[9] From Hammerwich. Light pink rock, looking much like a quartz-felsite. Under microscope, it shews porphyritic aggregates of largish rounded blebs of quartz, with Orthoclase (sanedine) crystals, somewhat decomposed, and also a little triclinic felspar; some Hornblende, much decomposed, with ragged edges, and what looks like a large crystal of Augite. The ground-mass is crowded with small rounded grains of quartz, which shew a mosaic structure between crossed nicols.

Quartz-felsite—? Lake District.

[1] From Brownhills. Dull pinkish rock with white flecks. Fragments which make up the rock are all more or less rounded, and evidently waterworn. They consist of quartz and felspathic or rhyolitic dust. Between the grains are small crystals of Calcite. The rock is very like some Uriconian ashes of Shropshire, but, for reasons stated above, probably comes from the Lake District.

Rhyolite Ash—? Lake District.

[2] From Cannock Chase. A bright red or pink rock, described as a Rhyolite in the field, which under the microscope shews an undoubted ashy structure. It is stained bright red with "ferrite," and shews a rough banding. The matrix is made up of felsitic dust, and is highly stained with iron; the fragments embedded in it are mostly angular pieces of quartz, lying in all possible positions, but running more or less in bands, as if from deposition. Here and there are larger fragments which look like felspar crystals, but replaced for the most part by granular quartz. Apparently the whole rock has been saturated with secondary silica. This rock again might be easily correlated with specimens from the Shropshire Uriconian Series.

Rhyolite or Felsite Ash—? Lake District.

[32] Peace's Farm. This "Rhyolite" consists of small angular fragments of quartz, set in a fine pink-coloured matrix, consisting of felspathic or felsitic dust. Darker bands, more highly stained, occur at more or less regular intervals, which gives the rock a distinct banded structure.

Rhyolite Tuff or Ash—? Lake District.

GROUP OF GLACIAL BOULDERS ON BROWNHILLS COMMON.

Robert Birbeck & Sons, Birmingham.

SECTION OF GLACIAL DRIFT AT HAMMERWICH.

Robert Birbeck & Sons, Birmingham.

SECTION OF GLACIAL DRIFT AT HAMMERWICH.

Robert Birbeck & Sons, Birmingham

BOULDER OF QUARTZ-FELSITE AND CLAY-IRONSTONE NODULE
AT HAMMERWICH.

Robert Birbeck & Sons, Birmingham.

1896.

Map Showing Distribution of Boulders East of Cannock Chase.

BY H. G. MANTLE, F.G.S., M.I. MECH. E.

SCALE. ONE MILE TO AN INCH.

0 1 2 3

RUGELEY (BONNEY)

PIPE RIDWARE

MAVESYN RIDWARE

BOND END

BARTON under NEEDWOOD

KINGS BROMLEY 200

ARMITAGE

Handsacre

203

ALREWAS

Riley Hill

Upper Longdon

LONGDON 314

LONGDON Green

CROXALL

PARK

BEAUDESERT HALL

(MARTIN) Hednesford

Littleworth

Wimblebury

Cannock Wood

RED MOOR

GENTLESHAW 547

FAREWELL

CHORLEY

CURBOROUGH

ELFORD

HARLASTON

LYNCROFT 350

CANNOCK (MARTIN)

FIVE WAYS 597

CHASE TERRACE

BURNTWOOD 400

LICHFIELD 255

Streethay

NORTON EAST

BALLS 564 MOUNT

EDIAL

Sandyway

WHITTINGTON NO BOULDERS

CHASETOWN

PIPE HILL

(MARTIN) CHESLYN HAY 380

GREAT WYRLEY

NORTON CANES

Cannock Chase Reservoir

HAMMERWICH 467

WHITTINGTON HEATH

NO BOULDERS

342 ARMY BARRACKS

Pipe Place 365

Moat Bank 328

WALL 369

NO BOULDERS

TAMHORN PARK

HOPWAS HAYS WOOD

HOPWAS HAYS

WIGGINGTON

Little Wyrley

Wyrley Common

Wyrley Grove

Mackley Corner 415

Summerhill

SWINFEN HALL

Chesterfield 329

HILTON 390

BROWNHILLS 495

SANDHILLS

LYNN 380

SHENSTONE 354

TAMWORTH

SHIRE OAK 576

UPPER STONNAL

LOWER STONNAL 400

NEW BARNS 360

WEEFORD 326 NO BOULDERS

ESSINGTON

PELSALL 480

WALSALL WOOD

HINTS No Boulders

BLOXWICH

Little Hay

MILL GREEN

WATFORD GAP

RUSHALL

ALDRIDGE

LITTLE ASTON HALL

HILL HOOK

DRAYTON BASSETT

HILL

WALSALL

FOUR OAKS

WILLENHALL

Explanation of Symbols.

Granites	×
Andesites & Tuffs	○
Syenites	△
Basalts & Dolerites	■
Rhyolites & Rhyolite Grits	▲
Sandstones, Quartz Felsites & Limestones	●

Ordnance Survey Levels are indicated by figures thus 235.

Robert Birbeck & Son, Lith. Birmingham

II.—*The Grey-Wethers or Sarsen Stones of Stanmer Park.*

By Jos. Landon, F.G.S.,
Vice-Principal of Saltley Training College.

[Read before the Geological Section March 24, 1896.]

Introduction.

Scattered over the surface of various districts in the southern and south-eastern counties of England—more particularly Kent, Surrey, Berks, and Wiltshire—are numerous blocks of a peculiar siliceous sandstone, locally known as Grey-wethers, Sarsen Stones, or Druid Stones. They resemble erratics in that they lie upon rocks totally different from themselves, while they are unlike erratics inasmuch as they cannot have travelled far, and seem certainly to have belonged to some bed that once existed over the areas where they are found, but which has now been removed by the action of denuding agents.

In some districts, more or less circumscribed, they are found in great numbers—as for instance about Marlborough, especially near the village of Kennet and in the valleys north of Pewsey—while in other places they are more thinly scattered among the grass and heather of the Downs, and not unfrequently they are found in the superficial beds of drift gravel where this exists. Their distribution seems entirely capricious, one side of a valley being sometimes thickly strewn with them while on the other they are entirely

absent; and over large portions of the country, where they might be expected, they do not exist at all.

"A few of the places where they are most numerous are marked as 'large stones' on the Ordnance map; but these yield no idea of their surprising number, or of the extent of ground they cover, no indication being given of their occurrence over many large areas, where they strew the ground so thickly that across miles of country a person might almost leap from stone to stone without touching the ground on which they lie." *

The colour of the sandstone of which they are composed, "varies," says Prof. T. Rupert Jones, "from brown to a yellowish tint and grey. In shape they are more or less quadrangular, longer than broad, and much broader than thick. They may be plane and smooth, or undulating and irregular with hollows on the surface. One face is usually flatter than the other. They often occur broken in two with a sharp, clean, straight fracture across their length." Many of the largest blocks are said to be four or five yards across, a few are larger, and some of those in the Abury circle are estimated to weigh between sixty and seventy tons.

Large numbers of the Grey-wethers have been destroyed, and some buried out of the way of the plough. Being the only durable stone in many of the districts over which they occur, they have been used in the past for cromlechs, stone circles, altar stones, and landmarks; while in more recent times they have been largely employed for building purposes, road mending, paving stones, gate-posts, stepping stones, &c. The great stones of the outer circle and the trilithons at Stonehenge are of Grey-wether sandstone, as are likewise the blocks forming the great circle at Abury (or Avebury), Kits Coty House near Aylesford, Wayland Smith's Cavern near Ashbury, and various other Druidical monuments of the South of England. Much of Windsor Castle is also said to be built of the same material.

The name *Grey-wethers* is clearly derived from the fact that as they lie in groups on the Downs, with their weathered and grey lichen-covered surfaces, they resemble, at a distance, a flock of

* Geological Survey Memoir of parts of Wiltshire, &c.—Sheet 34.

sheep; but respecting the origin of the term *Sarsen Stones* there is much diversity of opinion. The name is variously spelt Sarsen, Sarsden, Sarrazin, Sassen, &c. Some have thought that being considered outlandish, heathen, foreign, they were opprobriously called Saracen Stones, and that this has been modified into the common form. The Rev. John Adams suggests that the name is derived from Saxon *sar*, grievous or troublesome, and *stan*, a stone, and that the stones are so called because they proved a great trouble and hindrance to the early clearers of the land. Mr. Falkner thinks that as the Saxon word for rock is *ses*, plural *sesan* (the *e* being pronounced like the *ai* in fair), the term Sasen or Sarsen may be only a slightly altered form of the Saxon word for rocks. It has also been suggested that as there is a village named Sarsden (or Sarsen) near Andover in Hampshire, and another Sarsden in Oxfordshire, the name of the stones may be derived from that of the place. This however is unlikely, and the more so as there are no stones of the kind near the places mentioned.

A good resume (to which I am indebted for many of the preceding facts) of most of what is known about these peculiar blocks, and a useful bibliography of the subject, will be found in a paper by Prof. T. Rupert Jones, F.R.S., called a *History of the Sarsens.**

As he makes no mention of the remarkable Stanmer Park Stones, and I can find no record, either in the publications of the Geological

* The following referenees may also be useful :—

1. Memoirs of the Geol. Survey, &c. Parts of *Wiltshire and Gloucestershire.*—Sheet 34. By A. C. Ramsay and others (1858), pp. 41-43.

2. Memoirs of the Geol. Survey, &c. Parts of *Oxferdshire and Berkshire.* Sheet 13. By E. Hill, W. Whitaker, and W. T. Aveline (1861), pp. 47-48.

3. Memoirs of the Geol. Survey, &c. Parts of *Berkshire and Hampshire.* Sheet 12. H. W. Bristow and W. Whitaker (1862), p. 51.

4. Memoirs of the Geol. Survey, &c. Parts of *Middlesex, Hertfordshire, Buckinghamshire, Berkshire, and Surrey.*—Sheet 7. By W. Whitaker (1864), p. 71.

5. Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology, &c. 3rd edition (1862), p. 163.

6. The Geology and Physical Features of the Bagshot District. By Prof. T. R. Jones (1881).

Survey or elsewhere, of the occurrence of any Sarsens so far south as this, an account of them in their present condition may be of interest, and possibly of some service to future workers.

(1) *Mode of occurrence, size, &c., of the Stanmer Park Stones.*

The village of Stanmer in the centre of Stanmer Park—the seat of the Earl of Chichester—is about three and a half miles N.N.E. of Brighton. About four miles to the east is Lewes, some distance to the north is Ditchling, immediately to the north-west is Standean, and to the west is Patcham.

Alighting at Falmer Station, the beautiful valley in which Stanmer is situated runs N.N.W. towards the Downs, which stretch away northwards to Ditchling Beacon (858 feet). The gentle rounded slopes of the valley are dotted with fine trees standing singly or in groups, while here and there are larger tracts of wood, and a belt of woodland on the higher lands almost entirely encircles the park.

If only the Grey-wethers are sought the most direct course is to make straight for the village; but the whole district will repay examination, and it is better to ascend the high ground running northwards, and to keep up through the woods for a couple of miles or more. Stanmer lies down among the trees to the left, and a deep valley on the right runs roughly parallel to the ridge all the way. Beyond, to the the N. and N.E., stretch the Downs, whose fine sweeping curves melting into each other, rounded knolls, and bare white patches of chalk, reveal their character at a glance.

On reaching the northern end of the park and coming down westwards, on the inner side of the wood, to the road which leads up to the top of the valley from the village, the first stones are observed under some trees. These are three large irregular blocks of very hard and compact sandstone, varying in colour from white to reddish grey or brown. In shape they are roughly rectangular, with irregular surfaces, in some places rounded and worn as if by water loaded with sand, but many of the fractures have edges as sharp as if the blocks had at no distant date been removed from a quarry. They are not *in situ*, but have been brought to their present resting place out of the way of the plough.

The following are roughly the dimensions of the blocks:—

	Length.	Breadth.	Thicknses.
(1).	$9\frac{1}{2}$ feet.	$5\frac{3}{4}$ feet.	3 feet.
(2).	$6\frac{1}{2}$ „	$3\frac{1}{2}$ „	2 „
(3).	$4\frac{1}{2}$ „	4 „	$1\frac{3}{4}$ „

Resting as these masses of sandstone do in a position where a few inches below the surface there is nothing but chalk for many miles, and with no known bed of sandstone at present in existence from which they could have been derived, their occurrence is very striking.

Along the edge of a strip of woodland, skirting the ploughed slope to the west from which the large blocks came, are six others of smaller dimensions varying from a foot to two and a half feet in length. Generally these are of light greyish red sandstone, but one is a deep olive brown and of softer nature.

Proceeding up the slope a cart track is soon reached which has been mended with a number of smaller pieces similar in character to those already mentioned. On the slope lying in the direction of the village, amid a multitude of angular and rounded flints, small pieces of sandstone were occasionally seen, probably broken from larger masses which have been removed; one was bright green in colour, and distinctly flaggy in character. Round the edge of the wood at the top of the slope were some large blocks of flint removed out of the way of the plough, and among these were several other blocks of sandstone, the largest being about two feet square and a foot thick. This was of a dark brown colour.

Descending towards the village a good section of the lower beds of the chalk of the district may be seen in a pit among the trees near the road. The strata are much jointed and dip southwards at an angle of about 8°, but they roll somewhat, and probably rise to the north west.

On entering the village from the upper end, numerous large masses of sandstone are found placed along the strip of grass bordering the road. The approximate dimensions of the most important of these are given below.

	Length.	Breadth.	Thickness.
(1).	7 feet.	$3\frac{1}{2}$ feet.	$2\frac{1}{2}$ feet.
(2).	$4\frac{1}{2}$,,	$2\frac{1}{2}$,,	$1\frac{1}{4}$,,
(3).	$9\frac{1}{4}$,,	$4\frac{1}{4}$,,	$2\frac{1}{2}$,,
(4).	$3\frac{1}{2}$,,	2 ,,	$1\frac{2}{3}$,,
(5).	6 ,,	$2\frac{1}{4}$,,	$1\frac{1}{4}$,,
(6).	5 ,,	2 ,,	$1\frac{2}{3}$,,

Many smaller blocks may be found lying about, or built into the houses, or used for other purposes.

The larger masses are all angular or subangular, with worn and rounded faces here and there, but having very little of the appearance of travelled blocks. In general characters they are much the same as those first described. Judging from calculations made respecting blocks in other districts, the largest must weigh five or six tons, or more.

Lower down near the church another remarkable gathering is to be seen. The blocks have here been placed upon one another, along the margin of the road so as to form a low irregular wall, and smaller ones are continued as an edging round a small pool by the roadside. There are about two hundred of these stones large and small, ranging from masses $4\frac{1}{2}$ feet by 3 feet by $2\frac{1}{2}$ feet, down to lumps a foot or less in diameter. Some of the blocks are broken and angular like those already described, but many here are quite rounded into large shapeless lumps, while some of the smaller ones are not unlike large cannon balls. The largest block of this group stands by itself on the side of the road opposite to the pool referred to. It is hard and angular, with distinctly fractured faces, and measures six feet in length, five feet in breadth, and two and a half feet in thickness.

Proceeding along the road down the valley, about two hundred and fifty yards beyond the Hall, and some little distance to the right, another collection of some fifty large blocks may be seen. They are similar in character to the others, and vary in dimensions from 4 feet by 3 feet by 2 feet down to 2 feet by $1\frac{1}{2}$ feet by 1 foot. Nearly the whole of them are angular, with sharp edges, though a few of them are more worn.

Farther on, near the junction of the roads, are two other striking masses, evidently placed there as marked examples of these curious stones. The larger is 6 feet long, 4 feet wide, and 4 feet thick, and probably weighs about 5 or 6 tons; the smaller one is $4\frac{1}{4}$ feet long, $2\frac{1}{2}$ feet wide, and $1\frac{2}{3}$ feet thick. The former is angular and but little worn, the latter is much more rounded.

Thus altogether there are some 300 of these Sarsen Stones still in existence at Stanmer, and others are said to have been removed to another locality in the neighbourhood.

(2) *Locality from which the blocks have been removed.*

A pretty thorough examination of the whole of the valley and of the surrounding heights revealed nothing but chalk as the underlying rock, and except in one area this is evidently close to the surface everywhere. Careful inquiries upon the spot shewed that the whole of the sandstone blocks have been transported to the places they now occupy, in most cases to remove them out of the way of the plough. So far, also, as I could learn, all the Sarsen stones of the park have been taken from the broad slope which ascends from the village in a N.W. direction. None appear to have come from any other part of the valley, nor could I obtain evidence of the occurrence of any similar blocks anywhere else in the neighbourhood. This restriction to one slope and to a limited area of the valley is at least curious.

Beneath the slope mentioned the chalk strata appear to form a slight hollow, and the overlying beds from which the Sarsen blocks have been derived were perhaps longer preserved from the action of denuding agencies here than over the surrounding districts; or, possibly, the sandstone was, from some cause or other, more indurated in this area than in other parts of the neighbouring country, and hence more successfully resisted destruction. Anyway, there seems to be a greater accumulation of surface sand, chalk soil, and flint pebbles and fragments on the slope mentioned than elsewhere, and in this accumulation the Sarsens now occur.

The bed from which these blocks originally came was probably laid bare, broken up, and the surfaces of the hardened masses

exposed, at least to some extent, to erosion of sand-laden water and rolling pebbles, by the action of the sea in ages past. Any beds which once may have existed between the Sarsen bearing stratum and the chalk below, with the looser and softer portions of the sandstone itself and the upper layers of the chalk, were also washed away, or have been removed by denuding agencies since, leaving the hardened sandstone blocks stranded and more or less worn. In various ways, connected with water action, they may have been transported to some little distance from the place where they were formed, and broken through, or fractured by collision with other masses, until they arrived at pretty much their present state. The smaller blocks would be most easily moved, and hence, as a rule, would be most rolled about and rounded; while some, again, may have been more exposed than others to the violence of abrading agents.

The material in which the Sarsens are *now* found embedded may be nothing but a suface wash brought down by rain water from the higher grounds, its presence being in some degree due to the fact that among the blocks and fragments its downward transportation would be hindered; or it may have been accumulated on an old shore as the sea receded.

(3) *The Constitution of the Stanmer Sarsens.*

The blocks all consist of sandstones which have a general resemblance to one another, and in most cases have been more or less altered by the infiltration of silica and ferruginous matter. Some of the hardest and most compact have had the interspaces between the grains so filled up that they differ but little from quartzites.

In texture the stones vary from a fine close grained sandstone to coarse grits. Many contain small angular fragments of flint mixed with the sand, and the grains themselves are by no means uniform in size; in a few cases small flint pebbles occur scattered here and there in the sandstone, though none of the blocks I saw could be considered conglomerates such as are said to occur among the ordinary Sarsens in some parts of the south of England. A

considerable number are composed of what is known as "saccharoid sandstone" from its resemblance on fracture to the broken surface of loaf sugar.

So far as I am able to judge from examination, the cementing material seems in the great majority of cases—possibly in all—to be silica; and some blocks certainly shew curved markings indicating that they have been hardened out of loose sands by concretionary action. In most of the grits the majority of grains are seen with a magnifying glass to consist of transparent quartz, and where the darker patches occur the grains are coated with ferruginous matter. In some of the darkest brown blocks, however, many of the quartz grains are still quite clean, and the colour seems due to a much finer material in which the larger grains are embedded. Occasionally the rock contains a large number of small irregular cavities giving it a partially vesicular look; these may possibly be due to the mode in which concretion has been brought about, or to shrinking of the silica on hardening from the colloid form. In certain instances these cavities may have been produced by the washing out of fragments of clay or of some soluble material.

A few of the blocks have upon their surfaces curious little "pits" or hollows, an inch or two, or even more, in diameter, which may have been caused by the wear of small pebbles in swirling water, but more probably are due, in most cases, to the fact that from some cause or other the concretion here was less perfect, and the sand being less firmly held together by the siliceous cement was washed out.

Many of the larger masses are very hard, and break with a splintery fracture; but considerable difference of hardness is shewn, and some of the rounded stones have the appearance of ordinary sandstone, which would be worn down without much trouble. Some of the smaller pieces by the wood side, which have most likely been recently removed from the ground, are softer than the larger blocks, and it is highly probable that most of the masses have hardened on exposure to the atmosphere.

The blocks differ somewhat in colour, and even the same mass will often shew considerable diversity in this respect. The general

tint is a light greyish-red merging into brownish tints; but some of the stones are almost white in parts, a few a dirty yellow, and a large number a dull red sometimes deepening into a rich dark brown. Here and there greenish or bluish-grey tints are met with, but these are not common.

I examined the blocks carefully for shells, plant remains, or other trace of organic structures, but I was unable to discover anything which could with probability be considered such.

(4) *The Beds from which the Sarsen Stones were originally derived.*

The origin of the Grey-wethers or Sarsen Stones has been investigated by Prof. Prestwich, Mr. Whitaker, Prof. T. Rupert Jones, and others. All are apparently agreed that they have been derived from Tertiary sands of which they are the only remaining fragments in the districts where they occur. The two most probable sources are the Woolwich and Reading Beds and the Bagshot Sands; but some of the blocks in certain areas may possibly have been derived from the basement bed of the London Clay, which contains pebble layers, and others it may be from the Thanet Sands.

According to Prof. T. Rupert Jones, hardened masses of concretionary sandstone have been observed in a few places *in situ*, both in the Bagshot Sands and in the Woolwich and Reading Beds. It seems certain that in different areas the Sarsens have been derived from different sources. In some places, as at Little Maine, near Dorchester, blocks of concretionary sandstone have been found in looser sand beds resting on the chalk; and occasionally in other districts the Bagshot Sands are known to contain local beds of *sandstone*.

The Woolwich and Reading Beds thin out westward, and not far west of Marlborough they die out altogether. Hence, over the greater part of Wilts, the Bagshot Beds are brought down on to the chalk, and this is just where the Grey-wethers occur in greatest number. Here, at least, the blocks seem almost certainly to be derived from the Bagshots.

In Kent, Middlesex, and Hertford, the Woolwich and Reading Beds appear to have been the most prolific source of the Sarsen Stones. Mr. Whittaker and Prof. Prestwich think that most of the blocks scattered over Surrey and Berks were also derived from the same source; but at the western end of the London Basin—in West Berks and Wiltshire—they were probably mostly derived from the Bagshot Sands.

That *all* the Sarsens found in Surrey were not derived from the Woolwich and Reading Beds seems clear from the fact that they sometimes are found on a surface 200 feet and more *above* the Woolwich and Reading Beds which are still undisturbed below them.

Occasionally the blocks are conglomerates, and one, apparently *in situ*, at Hungerford is probably a hardened mass of the pebbly layers of the Woolwich and Reading Beds.

The London Tertiaries seem to have thinned out southward as they did westward, and it is highly probable that the Stanmer Park Sarsens are hardened masses and concretionary blocks derived from wasted Bagshot Sands which once spread over the district. As to whether the worn surfaces and sometimes rounded forms are due to knocking about on an old shore, or other similar action, seems uncertain, though the excavation of the Stanmer Park Valley and others in the neighbourhood appear to be due to marine action and not river cutting. It is quite likely that the apparently worn surfaces and rounded forms of the blocks are in some cases due to the way in which the beds were concreted, and that the surfaces mark where the indurating action became more complete. Whatever was the source of the blocks, that the beds were hardened in some places and not in others seems clear. The concretionary masses would resist denuding action, and be gradually let down by the washing away of the surrounding sands and pebbles, and the softer beds below. Where the Sarsen Stones were found, the uppermost beds of the chalk have also been worn off, so that, if this did not take place before the Tertiary beds were deposited, the descent of the Sarsen blocks must here have been considerable.

III.—*On the Geology of part of North-East Pembrokeshire.*

By Charles A. Matley, B.Sc.

[Read before the Birmingham Natural History and Philosophical Society, May 26th, 1896.]

1.—Introductory.—The district to which these notes refer is in the North-Eastern Division of Pembrokeshire, and ranges from the town of Newport and the river Nevern on the south, to the village of Moylgrove and Ceibwr Bay on the north, a distance of about six miles. On the west it is bounded by the coast, and it extends a few miles inland. While staying at Newport last year I made a general investigation of the geological structure of this area, and as the country is so little known to geologists the following observations may be of interest.

Little work has been done in this district since it was mapped by the Geological Survey in the days of De la Beche. The whole area, which mainly consists of slaty strata, is depicted on the Survey map as a monotonous stretch of purplish grey, expressive of Silurian age, only relieved by a sprinkling of orange dots along the coast to indicate the presence of sandstone among the slates. The surveyors mark it "*b 4*"—*Lower Llandovery.* In assigning the strata to this special Silurian horizon they were probably influenced largely by the conspicuous presence of grit beds which are so largely characteristic of this formation elsewhere.

Professor W. Keeping's paper on "The Geology of Central Wales" * touches on this area. He says, speaking of the Cardigan district, "The pale felspathic grits and black slates of Newport Bay and Cardigan hitherto placed in the Lower Llandovery series "b 4," are not of this age but belong to the Middle Bala or Caradoc group; as to this the fossil evidence is conclusive." This "fossil evidence" he gives the following year in a paper on "The Geology of Cardigan Town," read at the British Association Meeting and printed in the *Geological Magazine* (1882, p. 519), where he clearly shows from the graptolites which he discovered at Cardigan and which Professer Lapworth identified, that the series was certainly below the Llandovery and probably of Mid-Bala age. Nothing appears to have been done since that time, but the adjoining district to the S. and S.W. has been quite recently worked by Mr. F. R. Cowper Reed, whose "Geology of the Country around Fishguard, Pembrokeshire," appeared last year.†

2.—Petrology &c., of the District.—The district south of Newport is described by Mr. Reed as being covered by a succession of slaty beds (ranging from the Arenig to the Bala) with a general dip to the north, intercalated with volcanic rocks (lava flows, ashes, &c.), and the whole intruded by great masses of diabase, &c. These igneous rocks form the most striking scenic and geological features of that region, but when we cross the Nevern to the district under notice we note a great change. Both the contemporaneous and intrusive igneous rocks become conspicuous by their absence in the northern district, and black slates interstratified with grits everywhere prevail. The slates are perfectly black, and near Newport they are left unaltered as finely-laminated graptolitic shales; but, generally, they are cleaved. Quartz-veins occur occasionally along their strike. The grits first appear in the cliffs about three-quarters of a mile north of Parrog (the fishing village of Newport), and their incoming is marked by the presence of thin, pale-coloured, ashy-looking bands in the slates. These bands thicken as we advance up the succession, and by a rapid but perfect

* Quarterly Journal Geological Society, Vol. xxxvii (1881), p. 162.

† Quarterly Journal Geological Society, Vol. li (1895), p. 149.

transition pass into thick-bedded grits. The grits die out above, without attaining any very great thickness, by a gradual return to the black argillaceous slates. As we follow the coast or traverse the country northwards we come upon further tracts of grits (generally more or less intercalated with slate bands), each tract being bounded by outcrops of slates free from grits.

The grits themselves are generally compact and felspathic, sometimes of a dark bluish-grey, generally a paler grey when the felspathic elements are more noticeable, and then they present a very ashy look. They are sometimes conglomeratic, and slate fragments are frequently found in them. They bear the appearance of deposits resulting from the denudation of a volcanic area.

3.—General Structure of the District.—The strike of the beds is nearly due W. and E. in the south, with local variations; but as we approach Cardigan it twists towards a W.N.W.—E.S.E. direction, attaining in places even a N.E. and S.W. strike. The rocks have been thrown into a series of sharp undulations with vertical axes and show a continual succession of more or less compressed anticlines and synclines which are beautifully exhibited in the cliffs when the grits are present, but the folds are only occasionally visible in the black homogeneous slates. The centres of the anticlines are often eroded by the waves into small caves, and the skeletons of the synclines may be frequently seen protruding through the beach. The axes of the folds are then often seen to be gently tilted in the direction of their length, sometimes seawards, sometimes landwards—an indication that cross-folding agencies have been at work. The grits are often broken and slightly displaced along the synclinal axes, and water trickling down the fractures issues in tiny streams on the beach.

We are here on the slopes of the great syncline that lies between the anticline of St. David's and that of Harlech. To the south of our area, in the Fishguard district, we have an upward succession, as Mr. Reed shows, from the Arenig to the Bala as we advance northwards. Moreover, in the district beyond Cardigan, north of the country under description, the upward succession continues, so that it seems most reasonable to suppose that the

general northerly dip which prevails in the areas to the south and north maintains its constancy throughout our district, and that there are several sets of grits occupying higher and higher horizons as we travel across it in a northerly direction. On the other hand, our region appears to have suffered considerably more folding than the Fishguard district, perhaps due to the circumstance that the great intrusive masses south of Newport acted as resistant buttresses against which our sandstones were squeezed; and it is quite possible that there are only one or two series of sandy beds, repeated again and again by folding. The strata have been so "concertina'd," if I may so express it, that the same set of grits may have been brought up time after time. In this respect our region would resemble the southern uplands of Scotland and other sharply folded districts. I am inclined to the opinion that, on the whole, there is in our area a general dip to the north accompanied by much local repetition of the beds. The time at my disposal did not permit of my working out in detail the complicated structure of the district; but such facts as I obtained led to the above conclusion. The main difficulties were the poorness of the exposures inland, the homogeneity of the slates, the gradation of the grits, both upwards and downwards into slate, the want of a characteristic stratum to fix on as an index zone, and, finally, the rarity of fossils.

4.—Fossils and Age of the Beds.—The slates continue to be associated with grits as far north at least as Cardigan Harbour, and it was near Cardigan where Prof. W. Keeping found graptolites in some of the slates which fixed their age as Mid-Bala. The only forms which Prof. Lapworth recognised were *Dicellograptus Morrisii* (Hopk.) and *Diplogr. socialis* (Lapw.) The former is undoubtedly a Bala fossil "on or not far below the horizon of the Bala Limestone." Keeping also recorded* the discovery of some graptolites from "the cliff south of Pen Pistill, Newport Bay," but they were imperfectly preserved and could not be identified. There was a *Diplograptus* that seemed to be a very close ally of *D. modestus* of the Lower Birkhill shales, and a *Climacograptus*.

The name Pen Pistill does not appear on the new Ordnance map which I was using, but I came across several graptolite-bearing

* "Geology of Cardigan Town" (Geological Magazine, 1882, p. 519).

bands in a locality which I find on reference to the old map must have been near the place where Keeping found the above fossils. The bands occur near each other in the cliffs to the north of Newport Sands. The fossils are all in black shales, which dip at very high angles and split into extremely thin laminae. The graptolites are very closely compressed and are preserved as white films.

The southernmost band lies about 50ft. below the first appearance of the grits and close to a double cave; the next occurs within the first grits, the third about 5 yards north of a little waterfall where the stream from Ffynnon Dyfan tumbles on the beach. A fourth band is close by, round the next rock to the north, where grits and slates are interstratified. Forms of *Diplograptus* occurred in all these bands, but *Dicellograptus* and *Leptograptus* only in the last.

Miss E. M. R. Wood has very kindly examined, drawn, and identified these fossils. The most abundant form is a *Diplograptus* closely allied to *Diplo. foliaceus*, Murch., but apparently a distinct variety. The other species are:

Diplograptus euglyphus, Lapw.
Dicellograptus patulosus, Lapw.
Leptograptus flaccidus, Hall.

Miss Wood informs me that the specimens are noteworthy for their attenuated condition, there being a smaller number of thecæ per inch than usual in individuals of this species. This may, however, be possibly a phenomenon of distortion due to the extreme compression which these shales have undergone. I am much indebted to her and to Prof. Lapworth for their kind assistance with these fossils.

Passing from the first of these bands southwards across black shales and slates we reach, in a mile and a quarter, the highest fossil-bearing band found by Mr. Reed. This lies near Newport Castle on a horizon not far above the highest lavas and tuffs and Mr. Reed collected graptolites which Prof. Lapworth assigned to *Diplogr. euglyphus* (Lapw.), *D. foliaceus* (Murch.), large form, *D. truncatus* (Lapw.), or *D. perexcavatus*, and considered them "to be upper Glenkiln forms. . . . . At any rate they are cer-

tainly of Bala or of the very highest Llandeilo horizon."* Prof. Lapworth thinks that the fossils I discovered indicate an horizon intermediate between Mr. Reed's Newport Castle beds and Mr. Keeping's graptolite-bearing slates near Cardigan. The palæontological evidence therefore lends support to the opinion which I have expressed above as to the structure of the district and the place of its beds in the general succession of deposits of Central Wales.

Unfortunately I was unable to find graptolites elsewhere in this region, the only other fossils obtained being a few small brachiopods (*Obolella* or *Lingula?*) in slates at Velindre, and casts of crinoid stems, which were fairly abundant in some of the grit bands near the cliffs of Cell Howel.

I may add that the sandstones and slates of Dinas Island, on the opposite side of Newport Bay, which are shown in Mr. Reed's paper as "Llandovery (?)" are identical with the beds to the north of Newport, and may be safely classed as of Bala age.

5.—Drift.—The glaciology of the district deserves more investigation than has been given to it—in fact, practically nothing seems to be known concerning it—and I regret now that I did not give it more attention at the time. The smoothed rounded aspect of the country suggests land-ice, but I noticed no striated surfaces and only occasionally scratched stones and boulders. "Terminal curvature" in the slates is very common, but wherever I observed it the broken portions were turned downhill, and I considered the creep of the soil-cap would be sufficient to produce this phenomenon. Boulders (many being of igneous rocks) occur up to a height of 600 ft.—practically the highest ground of the district.

The most striking feature was a congeries of drift hills that stand out on the high ground which forms the watershed between Newport and Cardigan, at and for some distance around Pen Crugiau Cemmaes. They range from the 500 to beyond the 600 ft. contour lines; the summit of one hill is 642 ft. O. D., the highest point in the district. These hills consist in part of incoherent sands, in part of well-stratified shingle or gravel, with many

* Cowper Reed, Op. Cit., p. 156.

signs of current-bedding, In one pit the gravel was worked for 15 ft.—base not seen. These hills do not owe their form to denudation but must have been heaped up originally as rounded hillocks. Associated with them are a number of "crugiau" or tumuli. The constructors of these tumuli probably saved themselves trouble by merely accentuating the shape of the natural hills which they found ready to hand. The bulk of the contents of the gravels were of local material, but occasionally I found an igneous rock. Having, however, little acquaintance with the rocks of the adjoining districts, I could not locate the source of such specimens, but thought it possible they were derived from the Prescelly Hills to the South-East.

Prof. W. Keeping's paper on the "Glacial Geology of Central Wales"* states that the whole of the drifts of Central Wales are of local materials, the only exceptions being found on the extreme N. and S. borders of Cardiganshire. In the extreme north some ice flowed in from Cader Idris or the Aran Ranges. As regards the South, with which we are here most concerned, he says that around Cardigan "is a glacial clay of a different character. It contains slates (mostly), greywacke, much mountain limestone, old red sandstone, coal-measure sandstone, felsites, and greenstones. This deposit appears to have been formed by a large glacier which had its origin in the Caermarthenshire Hills of South Wales, where the Upper Palæozoic pebbles were obtained. Thence it streamed westwards, overriding the intervening watershed, and forcing its way down through the Teifi Valley to the Irish Sea. Boulders of the same rocks, foreign to the district, occur also in the country further north towards Aberporth, up to a height of 700 feet."

Now it seems evident at first sight that if the Teifi glacier left its spoor at a height of 700 feet on the north side of the Teifi Valley, it would also occupy the country on the south side to about the same height. This would mean its spreading over the watershed, flowing into the Nevern Valley, and occupying the whole of the district which I have been describing. But not a pebble of

* *Geological Magazine*, 1882, p. 251.

mountain-limestone did I see, nor a piece of old red or coal-measure sandstone!

It is clear, therefore, that there must have been some opposing agent that prevented the Teifi Valley glacier from overflowing its southern banks, and this was perhaps a glacier fed by ice from the Prescelly Hills, filling up the Nevern Valley, and uniting with the Teifi glacier. Such a coalescence of glacier streams may throw light on the significance of the drift-hills that occupy part of the water-shed. These hills may be aggregations of morainic material of the Nevern glacier, but they differ from a typical moraine in their stratified character and in the absence of angular boulders. In their formation water has evidently played an important part. I had not time to trace their extent and boundaries, and until this is done and the drift of the adjacent localities studied, suggestions as to the origin of these hills must be of very little value.

I ascertained, however, that *northern* ice must have swept over the district. On the cliffs, about half a mile S.W. of Ceibwr Bay, about 150 feet O.D., I found a round boulder of coarse granite. So round was it that I failed with the small hammer I was carrying that day to detach a specimen for examination, but it was conspicuous for its well-formed large porphyritic white orthoclase crystals. Another and larger granite boulder occurs at 450 feet O.D., about a mile and a half south of Moylgrove. This boulder, which must weigh more than a ton, and has been split by blasting into several blocks, occurs behind a cottage (Ty-rhos) south of the farm, Llwyn-gwydd. It is a coarse granite with black mica, white orthoclase quartz and hornblende, and has some resemblance to the Criffel granite of South Scotland. I have also found granite pebbles of a similar aspect to the above, along the coast, probably washed up by the waves. In addition to these I found a largish chalk flint in a pebble heap on the Cardigan Road, above Bayvil, at about 500 ft. O.D. I also noticed two granite pebbles of a different type to those already mentioned, in a gravel pit at Park Pratt on the way to Cardigan on the slopes of the Teifi Valley.

Dr. Hicks showed in 1891 to the British Association, and in 1894 in the *Glacialists' Magazine*, that northern ice, bearing

boulders of granite and picrite, etc., and flints, overrode N.W. Pembrokeshire to a height of 400 ft. at least. The evidence of the granites and the chalk flint that I have mentioned above proves, I think, satisfactorily that northern ice also impinged upon and overflowed N.E. Pembrokeshire to a height of at least 450 ft.; or, in the alternative (on the theory of a "great submergence") that there was a submergence in this district, during the glacial period, of at least this amount. The relationship, as regards time, of this northern ice to the more local drift of the district is a point that deserves investigation.

Attention may also be called to a small pre-glacial valley that is well exhibited in the cliffs close by the third graptolite band. It is filled up for perhaps 20 feet by a mixture of fine slaty material and clayey stuff, packed full of boulders of slate and grit, both rounded and angular, lying on the broken edges of the slates. I found no striations on the boulders. The stream from Ffynnon Dyfan has cut a narrow gorge through this débris down to and into the bed rock, and tumbles out to sea over the slates by a waterfall, 10 or 12 feet high. It is evidently, therefore, still cutting. Higher up the stream is a flat marshy expanse—perhaps the site of an old lake that existed before the stream cut through the dam of drift.

6.—Recent Changes of Sea Level.—Mr. Reed in his Fishguard paper* suggests a slight rise of this coast in comparatively recent times. I did not see any caves or terraces in the cliffs that would bear out this view, but in Ceibwr Bay, what seemed to be an old shingle, hardened in places into a conglomerate by a ferruginous cement, lies on the slates at a height of about 20 or 30 feet above tide. It contains *flints* among its pebbles. The little waterfall referred to above, at the juncture of the stream with the beach, may also be taken as supporting evidence of a rise. There is, however, clearer proof of a *depression*, for near Newport Sands a submerged forest is occasionally exposed after storms. A similar forest lies in Whitesand Bay, near St. David's, *vide* Dr. Hicks' paper in the *Glacialists' Magazine*, 1894, and another one in Cardigan Bay to the north.

* Op. Cit., p. 153.

7.—Summary.

1. The area is occupied wholly by black slates and shales interstratified with pale felspathic ashy-looking grits. The strike varies from E. and W. in the south to N.E. and S.W. in the north.

2. The beds are much folded, but there is probably a general dip to the north, and the grit beds may occur on several horizons. All the rocks are most probably of Bala age.

3. A cluster of hills of false-bedded gravel and sand occupying the highest ground of the district on and near the Cardigan Road, forms the most conspicuous feature of the drift. They range up to 642 feet O.D. Their significance requires further investigation.

4. Northern ice passed over the district to a height of at least 450 feet, as evidenced by granite boulders and flints.

5. There seem to have been oscillations of the coast in comparatively recent times. A slight depression undoubtedly took place, but the evidence for elevation is less conclusive.

IV.—*The Tides.*

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In giving the theories of the Tides we do not consider the whole rise and fall of the waters of the seas. There are some motions, rises and falls, which are not directly due to the attraction of the sun and moon, these are called meteorological tides. They are tides depending on the sun's heat, on the variation in the direction of the wind, the variation of barometric pressure according to the time of day, all causing currents which in turn cause rising and falling of the waters, and it is very difficult in observational work to separate these out from the rises and falls due to the sun's attraction, which are the true solar tides. The tides caused by the moon are simpler. We know that they are entirely due to the attraction of the moon, that they are wholly gravitational.

Consider now the direct effects of the sun and the moon on the water and for convenience work with the moon and the earth, the work, however, will apply, *mutatis mutandis*, to the case of the sun and the earth. Except where especially mentioned take that the sun and the moon move in the plane of the equator of the earth.

If the earth and the moon were both fixed, every particle of water would be attracted towards the moon, and resolving the attraction tangentially and normally to the earth, the diagram would be as in figure 1. The water would be pulled round and heaped up

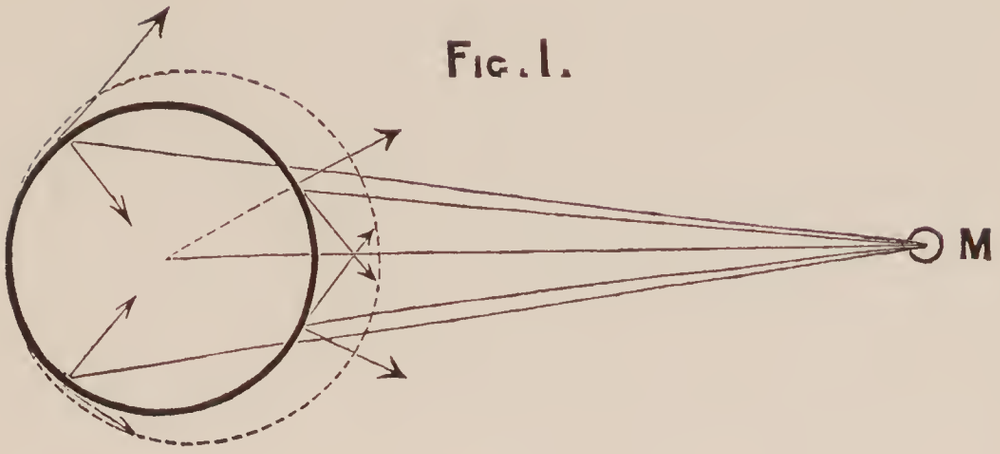


Fig. 1.

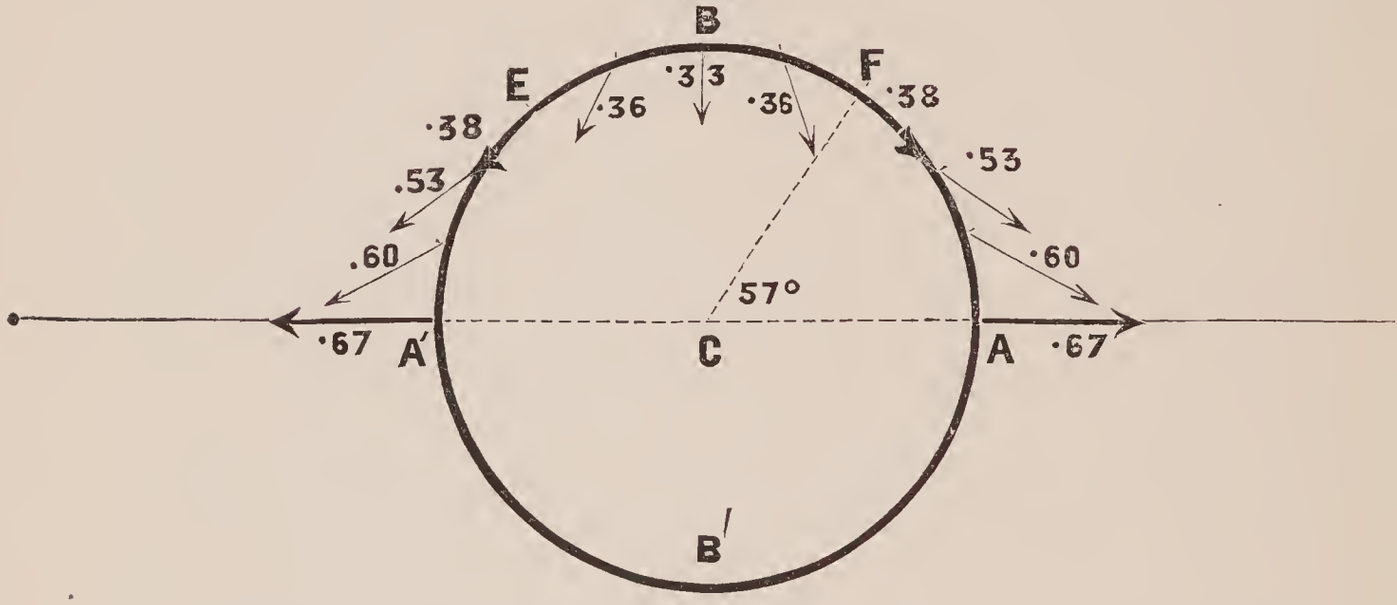
under the moon. If the earth were fixed and the moon revolved round the earth, just as we see later in the Kinetic theory, the water would not have time to take up this position, though it would have this tendency and we should get a wave travelling round the earth, with high water once in each revolution of the moon round the earth.

An apparent revolution of the moon round the earth takes about 24 hours, 50 min.,* and in this apparent revolution we have *two* tides, so that there is something of paramount importance omitted in the work just done. This is the fact that the earth is not fixed with regard to the moon (considering only the lunar tides) but the the two revolve round their common centre of gravity, a point about 3000 miles from the earth's centre. They do this under their mutual attractions, the attraction of the moon on the earth urges the earth towards this point and the attraction of the earth on the moon urges the moon towards this point, though they do not get closer to it, this attractive force on each body being balanced by the so-called centrifugal force on each as it moves round, so that under the attractions both move in curved orbits. If we consider the whole globe of the earth covered with water, then part of the water on the earth is nearer the moon and part further from the moon than the centre of the earth, through which passes the attraction of the moon on the earth as a whole, so that the attraction of the moon on some parts of the water is greater, on some parts less than the attraction on the earth; but

* See Godfray's *Astronomy*, § 311.

the waters go round as a whole with the earth, so that the forces on them causing them to move on the earth are those due to the excess of the attraction of the moon on the water over that on the earth as a whole or to the defect of the attraction of the moon on the water from that on the earth as a whole. This excess or defect is called the tide-generating force. We proceed now to draw a diagram of this tide-generating force. The process of finding this is worked out in Bryan and Barlow's *Mathematical Astronomy*, § § 440-442,* and a diagram is also given there, the one I give (figure 2) is taken directly from Darwin's paper on "Saturn's Rings," *Harper's Magazine*, vol. lxxix, p. 71.

FIG. 2.



The numbers represent the ratio of the forces at the corresponding points. At the points marked E,F the force is tangential, the angle FCA being about 57°. The forces at A and A′ are, note, not absolutely equal, but very nearly so, owing to the smallness of CA compared with CM. From A to F the effect is to lift the water and at the same time pull it towards A, from A′ to E to lift it and pull it towards A′, and from E to B to depress it and pull it towards A′ and from B to F to depress it and pull it towards A. Precisely similar results hold for the other half of the circle, and also for any other circle on the earth with AA′ as diameter. This is how the water gets heaped up at A and A′, though it is often

* Note a slip on p. 376, line 9, B should be A′.

thought that the attraction of the moon actually lifts the water at A and pulls the earth away from the water at A′. This is wrong, for there is another force acting on the water, the attraction of the earth on the water round it. The water at A is pulled towards the earth by this, so that while the water at A is attracted towards M that attractive force does not by any means conquer the attraction of the earth. In fact the tide-generating force at any point of the earth is excessively small compared with gravity, at A, for instance, it is roughly one ten-millionth of it. In other latitudes it is less, and the tangential component of the tide-generating force is also extremely small in comparison with gravity.

The motion of the water under these forces in our diagram is a problem of extreme difficulty and even with assumptions about a uniform depth over the ocean or a uniform depth throughout any parallel of latitude only an approximative solution has been worked out; this was done by Laplace* towards the end of the last century, and the solution has been simplified first by Airy,† and later by Lord Kelvin and by Darwin.‡ But when in order to get a true theory we should take into account the irregular distribution of land and water, the variable depth of the ocean, the friction of the water &c. &c., the problem becomes too complex for the mathematics we have.

In many books the Equilibrium Theory, first mentioned by Newton and later elaborated by Bernoulli, whose name it usually bears, is the only explanation of the tides; it is necessary then briefly to explain it and point out where it is wrong. Briefly the theory is this: "In any position of the earth and the moon, the water at once assumes the shape in which it would be in equilibrium under the tide-generating forces in this position." From the diagram we see that the effect of the forces is to make the water flow towards A, A′ and be heaped up there, not by the pull on the water at A, A′ as has been already mentioned, but by the tangential forces; this would give us the water in equilibrium in our figure

* *Mécanique Celeste*, Book 4.

† *Encyc. Metrop.*, "Tides and Waves."

‡ *Encyc. Britt.*, "Tides."

in the shape of an ellipse with long axis in the direction AA′, or high tide at A and A′, low tide at B and B′. This position is to be assumed at once in every position of the earth and the moon, thus there is high tide always under the moon and away from it. In 24 hours 50 min., the moon returns again to be over the same meridian, thus in this time we get *two* high tides and *two* low tides. It is sometimes asked, is the rotation of the earth taken into account in this theory? Yes, it is, but as the water is at once to assume the equilibrium position in any position of the earth and moon, it does not affect the theory. The equilibrium for the water over the whole globe is got by rotating this ellipse round its major axis AA′: according to this theory then the high tide at any place is when the moon is on the meridian through it and is higher the nearer the moon is to the zenith.*

The position of the water at any moment is treated as a statical question, and that is where the theory is quite wrong. Water cannot at once take up one position of equilibrium from another, it has the property of inertia and it will move to the next position of equilibrium and rush beyond it. The question of the tides must be treated as a dynamical problem and it is this which constitutes its difficulty. When the moon shifts its place, we have to consider not only its instantaneous action tending to produce a certain form for the water but also the effects of the shape, velocities and pressures due to its past action and still subsisting. The problem of the tides is to find some state of disturbance, some combination of shape and velocities such that, once supposed to exist, these combined causes will exactly keep it up. The principle used by Laplace in his solution was "The state of oscillation of a system of bodies in which the primitive conditions of movement must have disappeared through friction is coperiodic with the forces acting on the system when the squares of the displacements and the velocities are neglected." This is the principle of forced oscillations,† which received a formal proof from Sir John Herschel.‡

* Godfray's *Astronomy*, § 378.

† *Encyc. Britt.*, "Tides," § 4.

‡ *Encyc. Metrop.*, Art. 323. Also *Outlines of Astronomy*, § 650.

Hence if the sea is acted on by a periodic force expressed as a coefficient × the cosine of an angle which increases proportionately with the time, there results a tide, also expressed by the cosine of an angle increasing at the same rate but the phase of the angle and the coefficient of the cosine in the expression for the height of the wave at any place may be very different from those occurring in the corresponding term got by an equilibrium theory. If the free periods of the masses of water found on the globe were small relatively to the periods of the operative forces, which they are not, then the inertia of the water might be omitted and good results obtained by an equilibrium theory.

A special case has been worked out, the results of which will exemplify the principle of forced oscillations and lead up to the general results for the earth. This is the case of a canal of uniform depth round the earth along the equator ;* consider the effect of the moon on this and only consider the forced oscillations, supposing the oscillations that could have existed by themselves, once set up, extinguished by friction. The moon moves in the equator and the diagram of forces round the canal is precisely as we have drawn before, and as the forces are symmetrical on the two sides of AA′, the force at A as the moon moves round is precisely the same by the time the moon has got to opposite A′, that is the period of the disturbing force is half the time taken by the moon relatively to the earth to go round. The produced oscillation, or tide, has then this same period, 12 hours 25 min. approximately, but the tide is direct or inverted, that is, there is high water under the moon or low water under the moon according as $c \gtrless na$, where $c^2 = gh$, h being the depth of the canal, n the angular velocity of the moon relative to the earth, a the radius of the earth, and g the gravity constant, corrected for centrifugal force for that tends slightly to counteract gravity ; that is, according as the linear velocity of a point relative to the earth's surface on which it moves so as to be always opposite the moon (na) is less or greater than the velocity of a free wave ($\sqrt{gh}$). This condition gives, putting in the values of n, c, &c., according as $311h \gtrless a$. If then the tide is direct $311h > 4000$

* Lamb's *Hydrodynamics*, § 178.

miles, or the canal is about 13 miles deep, far beyond the depth of our oceans, so that with a canal of the average depth of our ocean the tide will be inverted. An interesting result follows too if we consider a canal in a parallel of latitude, not in the equator, under the same conditions.* As before we get the period of the tide to be 12 hours 25 min. and here the tide is direct or inverted according as the linear velocity of a point on the canal relative to the earth, on which it moves with the same angular velocity relative to the earth as the moon (here $na\sin\theta$, where θ is the latitude) is less or greater than the velocity of the free wave, or according as $c \gtrless na\sin\theta$. Reducing this condition, we find that if $311h \succ a$, the tide is direct, as before, but if $311h \prec a$, the tide is direct or inverted in latitude θ if $\theta \gtrless \cos^{-1}\sqrt{(311h/a)}$, and the nearer the canal is to the pole the greater the chance of the tide being direct.

It may seem paradoxical that at the place where the disturbing force is greatest the oscillation is not greatest but we can show an analogous result in a simple case. Here our result is that the period of the tidal disturbing force is about 12 hours 25 min., but if a free wave were set up in the canal taken about 11250 feet deep, nearly what exists in the ocean, it would take about 30 hours to describe the earth's semicircumference. This is then the case of a slowly oscillating system acted on by a more quickly varying force. Now take a long pendulum, a slowly oscillating system; move its support more quickly backwards and forwards, the bob will not be on the same side of the equilibrium position as the support.

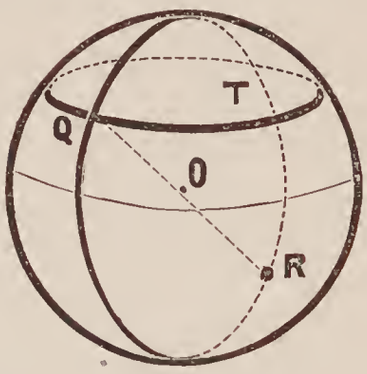
I regret that I cannot give the solution of the oscillations in these canals, much less in the general case of water over the whole globe without more mathematics than I wish to use in this paper; I must refer the reader to Lamb's *Hydrodynamics* for the solution, if wanted. I feel, however, I must protest against such a non-mathematical exposition of the canal theory as given in Bryan and Barlow's *Astronomy*, § 445. The "proof" there ought to hold for any depth, but the true theory shows that if the canal is deep

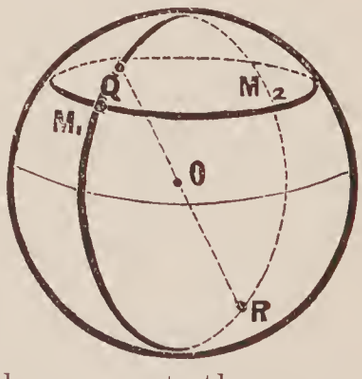
* Lamb's *Hydrodynamics*, § 179.

enough the tide will be direct; but the worst point is that it seems to speak of the motion of an actual mass of water; the tides are only a propagation of a change of shape, as one sees well when one looks at a field of corn with the wind passing over it.

In stating the results obtained by Laplace it will be well to speak of them in conjunction with the various tides which exist, the combined effects of which are what is apparent to us. We wish the periods of the tide-generating forces and then we shall know the periods of the tides.

We have seen that taking the moon to go round in the equator the tide-generating forces from the moon have a period of 12 hours 25 min.; this gives rise to the ordinary lunar semi-diurnal tide. Now the moon does not revolve in the equator, its orbit is inclined to the equator, hence its declination varies, but suppose in any one day its declination constant or that it appears to move in a plane parallel to the equator and to describe a small circle. Let the moon rotate apparently in the small circle in the figure, at Q a point on the earth it is vertically overhead or it is in the zenith, so that there is at Q either high tide or low. At R, the antipodes to Q, there is the same high or low tide. But 12 hours 25 min. later the moon crosses the meridian through Q at T so that although there is again high or low water at R, as the moon is then nearest the zenith of R, and also at Q, it is not so pronounced as the moon is not in the zenith at R. The effect will also be marked in a similar way at the places where the moon is not at any time in the zenith, for at M_1 the distance of the moon from the zenith of Q is less than its distance at M_2 from the zenith of R, the antipodes of Q. Consequently we have two high and two low tides in the day which are not the same for places not on the equator. This inequality in the two high and low tides and in the disturbing forces is best represented by combining with a variation, period 12 hours 25 min., a varia-





tion, period 24 hours 50 min., or in the case of the tides combining a tide, maximum height twice a day, with one, maximum height once a day. The former is the lunar semi-diurnal tide, the latter the lunar diurnal tide, and the latter, we see, depends on the difference of the heights of the two high tides at any place; this difference vanishes when the moon is on the equator, that is, the lunar diurnal tide vanishes once a fortnight. The moon revolves round the earth in space once in a month and as the orbit is not circular we get variations in its distance, hence variations in the forces, but as the orbit is symmetrical the cycle of variations is gone through twice a month, so we get variations of a fortnightly period; this again is taken separately and we suppose that on the previous oscillations a fortnightly oscillation is superposed, this is called the fortnightly tide and the oscillations of the water due to the moon are supposed to be made up of the oscillations of these three types. There are other variations of the moon's force due to changes such as nutation, but they are small and we shall not go into them.

Just in the same way as we have these tides from the moon, we have a semi-diurnal solar tide, reckoning now the solar day, 24 hours, a diurnal solar tide and a six-monthly (half a year) solar tide due to the sun. The solar diurnal tide vanishes as in the case of the lunar when the sun is on the equator, that is at the equinoxes and near them, or roughly in spring and autumn the difference between the two solar high tides in a day is inconspicuous and the diurnal tide small, but in summer and winter the diurnal tide is larger.

In solving the general question of tides we write down the hydrodynamical equations of motion, simplified as far as possible by the knowledge that the depth is small compared with the radius of the earth; from these equations, as we know that the position of relative equilibrium, if there were no disturbing forces, under gravity and centrifugal force is a spheroid of small ellipticity with axis of revolution the polar axis of the earth, we find the equations for the oscillations about this position of equilibrium, then we solve these for each of the oscillations or partial tides mentioned above.

For the lunar semi-diurnal tide and the solar semi-diurnal tide, which for an approximation are taken to have the same period and form one tide, a somewhat rough approximation, it is true, we find that for the special case of depth varying as the square of the cosine of the latitude* in which the ocean shallows to the poles the tide is inverted, low water under the moon, and also that in a sea with depth 3000 fathoms at the equator and following this law, the height of high tide at the equator would be the same as that given by the equilibrium theory. For the same tides, however, if we take an ocean of uniform depth covering the earth,† the approximation to the solution is very awkward, and Laplace's work was attacked by Sir George Airy‡ but defended by Lord Kelvin,§ and now the work is admitted to be correct. Some of the approximate numerical results got in this case are—

Depth/radius of earth.	Depth in feet.	Max. rise of water between high and low tide at equator.
$\frac{1}{3000}$	7260	$-7{\cdot}4 \times H$
$\frac{1}{700}$	29040	$+11{\cdot}2 \times H$
$\frac{1}{360}$	58000	$+1{\cdot}9 \times H$

where H is the maximum rise on the equilibrium theory and the minus sign shows the tide is inverted, plus direct. The greater the depth we see the nearer the height to the equilibrium value. For depths of 30000 feet and upwards, this tide over the whole surface of the earth is direct, but there is some critical depth between 30000 and 14500 feet for which at the equator it changes from direct to inverted. There is probably too a second critical value somewhat below 7000 feet. As we always have this tide direct at the poles, when it is inverted at the equator we shall have a nodal curve, points of no oscillation: in our first case, depth about 7260 feet, we get tides inverted in the zone between 18° N. and 18° S., and everywhere else direct.

* *Encyc. Britt.*, "Tides," § 15: Airy, "Tides and Waves," and Lamb's *Hydrodynamics*, § 213.

† Lamb's *Hydrodynamics*, § 214. *Encyc. Britt.*, "Tides," § 16.

‡ Airy, "Tides and Waves."

§ Sir W. Thomson, "On an Alleged Error in Laplace's Theory of the Tides," *Phil. Mag.*, Sept., 1875.

For the diurnal lunar or solar tide,* which for an approximation we take to have the same period, we get that if the depth follow the law $h \propto 1 - q \sin^2\theta$, where q is a constant and θ is the latitude the equation is integrable and we find that for such depths as actually occur in the ocean the tide is inverted. For an ocean of uniform depth we get the striking result that the diurnal tide vanishes.

For the long period tides† we find that they are in general direct and that for depths comparable with the actual depth of the ocean these tides have less than half the value they would have on the equilibrium theory. With increasing depth of ocean the heights of these tides approximate more and more to this equilibrium value. The theoretical results, however, are far from agreeing with the observed results but the shape of the land at any part of the earth must modify very much the tides; we have for instance that all over England and the North of Europe the diurnal tide is extremely small compared with the semi-diurnal, and so we notice only the familiar twelve hourly (nearly) semi-diurnal tide with the regular inequality of spring and neap tides, but in some places in the Pacific, China Sea, &c., at some times of the month the inequality of the two high tides is so great that one is practically unnoticed and the tide is practically a diurnal tide. This and many other things still require a satisfactory explanation.

The ordinary terms "spring tide," "neap tide," &c., I have not explained here, they are given in all text-books, but one use of the word "tide" may be mentioned: in a sailing chart one will find the Firth of Clyde, for instance, marked "no tide here," and yet there is a rise and fall of ten feet; what is meant by this is that there is no appreciable current with the rise and fall, and it is the current up or down that is useful to the sailor.

* *Encyc. Britt.*, "Tides," § 14; Lamb's *Hydrodynamics*, § 212.

† *Encyc. Britt.*, "Tides," § 18; Lamb's *Hydrodynamics*, §§ 209, 210.

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